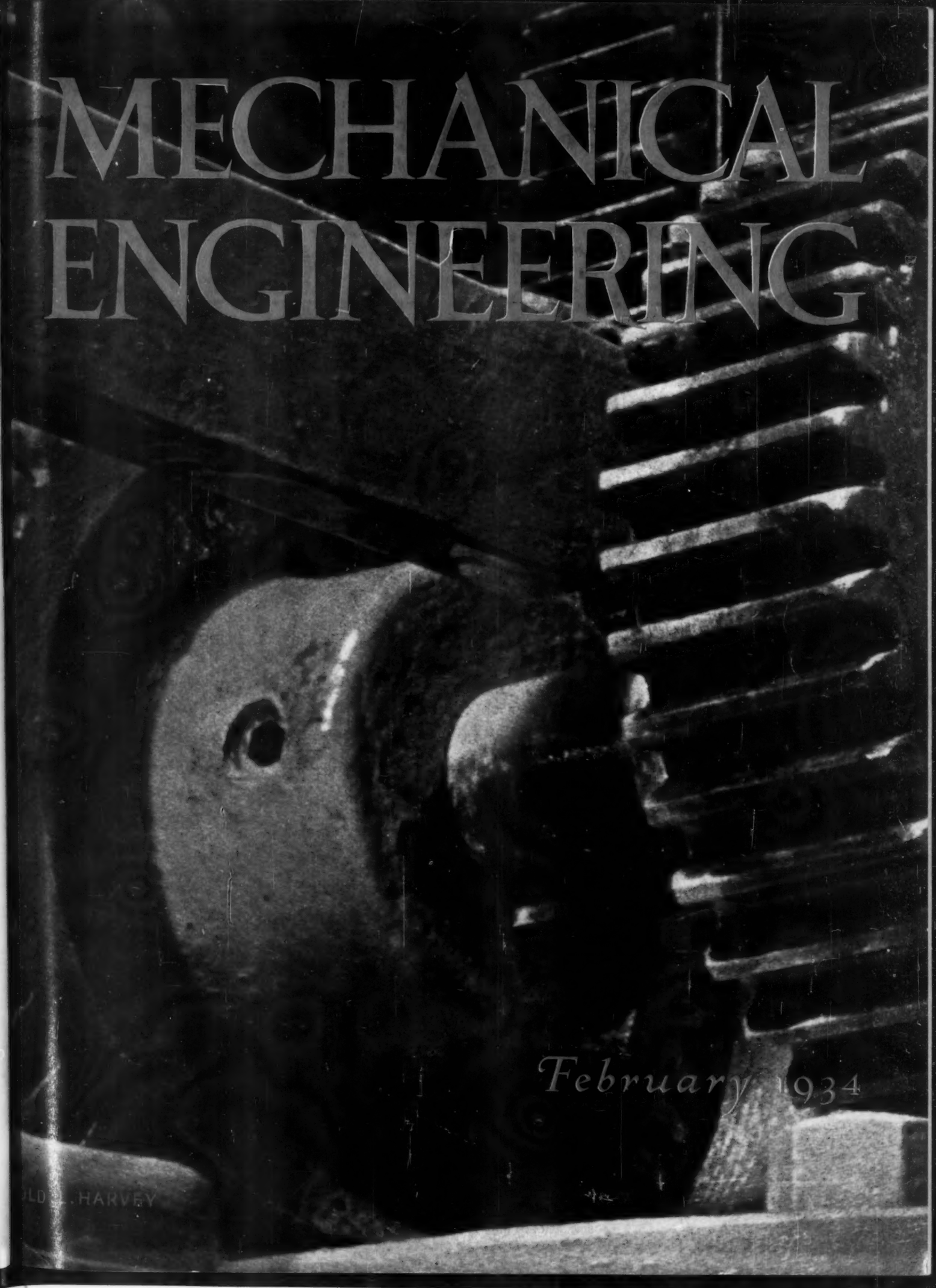
MECHANICAL ENGINEERING



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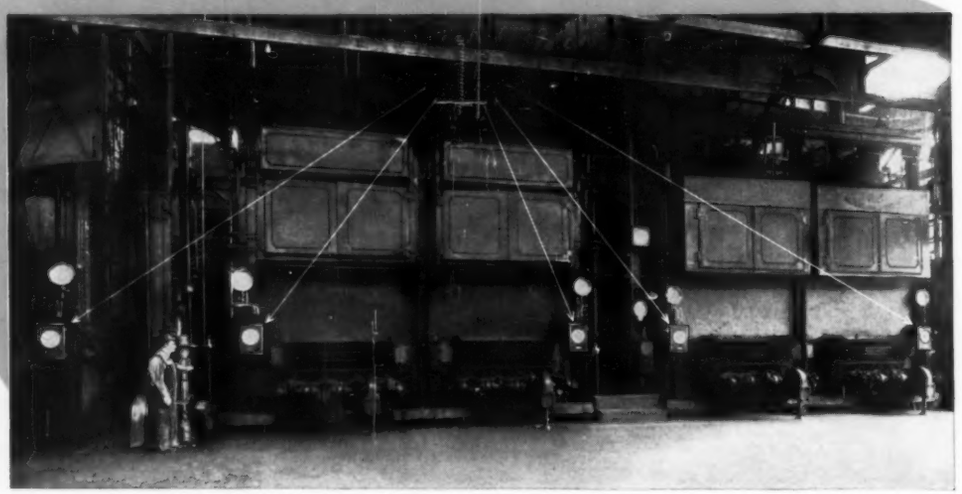

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Robert Dudley Smith

Topping the Grade

OBJECTIVITY *in* ECONOMICS

What Industry Wants Engineering Students to Have in the Way of Economic Training

By RALPH E. FLANDERS[1]

THE FIRST QUESTION raised by the topic assigned me is this: What is industry? If industry or business is one kind of activity, it is best served by one kind of economic training. If it is of some different sort, another variety of training is indicated. This matter is of such importance that I wish to sketch in rather hastily the present outlines and possible effects of that form of activity which is socially useful and which has some chance of survival, and for which, therefore, it would seem wise to train our students.

The term "industry," or the broader term "business," in this connection is confined in its application to those activities involving land, labor, capital, and management, which are essentially wealth producing, whether in the fields of extraction, manufacture, transportation, distribution, or finance.

There are other activities which are not productive but destructive, and thus do not deserve the honorable name of "business." They are to be found to a certain extent within the structure of business properly so-called, in the form of unfair and harmful trade practises; but their greatest development has been as malignant financial and speculative growths which are for the most part engendered and nourished by social groups who cannot properly be called "business men."

There has been a failure on the part of honest observers of the industrial process to distinguish between true business and these parasitical practises. This failure to distinguish threatens business with kinds and degrees of control which will seriously curtail its ability to produce and distribute wealth.

PRODUCTIVE CAPACITY IS ADEQUATE

The productive capacity of business is such that if it is fostered in its present and future development it can increase the production and distribution of wealth to *all* producing classes of society, to the disadvantage of none.

Continued improvement in machinery, processes, and management will operate, as in the past, to increase the spread in a favorable sense between wages on the one hand and the prices of consumer goods on the other; in other words, it will raise the standard of living which has never been anything but miserably low for millions of willing workers, even in our periods of greatest prosperity. The continued profitable operation of industry is dependent on this social improvement.

The Government is making unprecedented expenditures to relieve destitution and increase employment. These expenditures can be continued and the accumulating indebtedness can be discharged from only one reservoir of wealth—the profitable operation of constructive business.

COOPERATION OF BUSINESS WITH GOVERNMENT

As this crisis is liquidated and business again takes a more normal course on a higher plane of productiveness, it may well offer to support an advance in social standards whose beginnings are already foreshadowed in recent Administration policies. In cooperation with Government, it can secure that fundamental human right in an industrialized society—the right to work at socially useful tasks for subsistence wages. If given freedom to produce, business should be able to underwrite that social policy in good times or in bad, whether for thousands or millions, and still be able to reabsorb these workers into its normal operations in the degree that those operations are restored.

The unrealized productive capacities of business are such that, if we are wise and prudent in our policies, even further social sureties may be established in their turn, and all without reducing the returns to any productive element of society.

The fostering of healthy enterprise in business will benefit agriculture in two ways—by lowering relatively the prices of goods which the farmer buys, and by raising relatively the prices of the products he sells. It can effect this spread more surely than it can be accomplished by any imaginable monetary policy, and on a more permanent basis than by any elaborate mechanism of control.

Prices of goods purchased can be lowered for the farmer as for the worker by encouraging the progress of improvement in industrial production instead of discouraging it.

The process of raising the prices of farm produce is more indirect but is fundamentally sound. Farm produce is largely, though not entirely, composed of items of comparatively inelastic demand. The products of manufacture are largely, though not entirely, composed of elements which have a very elastic demand, contributing to unsatiated desires of masses of unsatisfied people. Under proper development, business must therefore be expected to grow relatively to agriculture.

[1] President, Jones & Lamson Machine Co., Springfield, Vt. Mem. A.S.M.E.

Contributed by the Committee on Relations With Colleges, and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Farmers producing under marginal conditions will be drawn into the more profitable operations of industry, thus reducing agricultural supply more nearly to fit the inelastic demand, and raising prices in the process.

This is the natural, unregimented remedy; and it applies as well to other overdeveloped occupations, such as that of soft-coal mining, whose problems will never be settled with the best will in the world, until the number of miners is reduced.

The generous profits from a free and healthy development of business form the only source from which the Government can finance its present lavish expenditures and the more considered expenses of a developing social program.

There is a current skepticism as to whether development can take place in the future on anything like the scale of the past. This skepticism, so far as it is rational rather than emotional, is based on the fact that our physical frontiers have disappeared, and with them has gone the incentive to exploration, discovery of new resources, and immediately profitable exploitation. But there are yet frontiers to be occupied, not territorial, but social; and as soon as the realization of this fact comes to the general mind, there need be no lack of forward impulsion and stimulus. Without detailed description, let me urge on your imaginations the undeveloped possibilities of raising the general scale of living to agreement with our productive powers; and the unrealized advantages of social consumption, whose importance will grow as individual needs are satisfied.

CHANGE IN ATTITUDE NECESSARY

It is evident that the social and economic benefits just described cannot be attained without important change in attitude and policy on the part of all elements in the social structure.

Labor must be willing to govern its requests by the overall requirements of the industrial process, and not by the immediate self-interest of any restricted group.

Financial interests must refrain from building top-heavy credit and speculative structures, and must be willing to look to true business service for their profit.

Government must distinguish between business in its proper sense and destructive practises which are unworthy of the name, leaving the former with adequate freedom while it restricts the latter. It must provide the mechanisms for distributing the unemployed to occupations where they are needed, and for furnishing an adequate volume of subsistence employment on socially useful work. It must provide a "sound" monetary and credit system of reasonably steady purchasing power—these two characteristics not necessarily being contradictory; thus will business and agricultural operation be steadied, and financing for improvement and expansion be assured. Finally, it must be prepared to assist in all the processes before and hereafter described, preferably by permissive rather than by restrictive action, but with such authority as may be required.

If business is to serve the social purposes outlined above, and serve its own interests in so doing, it must discipline itself, or submit itself to be disciplined, in several particulars, among which are the following:

Business must not be shortsighted in its distribution of the returns from an expanding industry, but must give due shares to labor, to the consumer, to management and to capital.

Business management must be content with business profits, and not make its principal interest the search for illusory and unsocial speculative gains.

Business must not seek to protect itself unduly, but must be willing to undergo the dangers of such a degree of competitive freedom as will insure the orderly and continuous application of improved processes for the general good.

Business must be willing to outlaw those forms of competition which are in the long run socially destructive, even though immediately profitable.

Business must cheerfully accept proper taxation for socially desirable purposes, and be willing in other ways to submit to that minimum of governmental control which the general interest requires.

The progress described, based on business enterprise and development, is physically attainable. The resources of our country, the advance of science and technology, and the capacities of our population are all adequate. Only in its social, economic, and governmental aspects need there be fear of failure.

It may be said with confidence that as a problem of control such a development is not a matter of detailed planning, or of the application of any one social or economic cureall. It is believed that the present knowledge of our authorities in business, finance, economics, engineering, and government is such that a good beginning may be made now, provided that this knowledge is organized and coordinated.

As to the vitally necessary cooperation of all the elements of society, it would seem that a beginning made now by business in evident good faith reinforced by the evident possibility of advantage to all, would serve to bring the initiation of the project within the possibilities of skilled human leadership. Its continuance through the coming decades depends on the training and on the mental attitude of the engineering and industrial leaders of the future, now being graduated from our schools.

DAY OF SOCIAL ENGINEER HAS COME

It is fitting that we should have digressed so far, since that wandering from the subject was in search of a purpose, and without a purpose engineering has no existence. Herein it differs from pure science, which pursues knowledge for its own sake. Engineering pursues and appropriates knowledge for the sake of reaching some practical end. Science was barren of important effects until the engineering mind and method were born. With the engineer as the agent, science remade the world.

The social sciences (of which economics is a branch) have lagged in their practical application for two very

evident reasons. In the first place, being tied in with human emotions and reactions, they have lacked the definiteness and calculability of the physical sciences. This handicap is being overcome by a growing appreciation of its nature and by the growing effectiveness of the statistical method. The second handicap has been the lack of a definite pressing problem to which the findings of the science can be applied. This problem we are now prepared to pose, as being the attainment of a normal, socially useful business structure, of the kind or for the purposes described in the opening paragraphs of this paper.

While it has been the case hitherto that those concerned with and responsible for social policy were untrained in the science, while those trained in the science were uninterested in policy, or unfitted for determining it, the time has now come when the determination of policy can and must be made in the light of the best available scientific knowledge. The day of the social engineer has come.

HOW TO TRAIN THE SOCIAL ENGINEER

I now come directly to my topic. How may the social engineer best be trained? I am unfitted to suggest how many hours of training should be devoted to this element of the curriculum. The difficulties of finding time for it in the crowded engineering curriculum are obvious. It will be more easy and perhaps more important to outline the character of that training rather than its amount.

Gerald Young

In the first place, neither teachers nor pupils should be required to pursue the science of economics for its own sake. The end product is the social engineer, not the cloistered student.

A high degree of objectivity must be cultivated. This is difficult in any subject, even those related to impersonal reactions of flowing fluids on moving vanes. There is always pride of design and discovery to be reckoned with. In the social sciences, and particularly in economics, the preservation of the intellectual attitude is infinitely more difficult and infinitely more necessary. The vision of human maladjustments and wrongs fires the emotions and warps the judgment, at the same time that it gives point to the urgency of the problem. Thus objectivity in teacher and student becomes a prime consideration.

Open-mindedness and a wide range of consideration will be the needed result of objectivity in a flexible mind. Consideration and assent will not be confined to narrow lines of inquiry, however valid. All hopeful points of view—even the more rugged of the heresies[2]—will have sympathetic attention. Each doctrine will be considered in the light of the others, so that a well-rounded and consistent structure can be built up, tested as to its usefulness for practical purposes.

Finally, there must be developed in the mind of the teacher and by him transmitted to the student a clear picture of the physical possibilities for human values in the engineering-economic complex for which he is being trained. From this clear picture there must be drawn a faith and a will to act, firmly based on these reasonable physical possibilities. Here is the proper field of the emotions, not as a directing force for the intelligence, but as a driving force for the will. If the rational training does not develop and properly direct this emotional force, the education of the student will have failed in its office.

The training here suggested for the social engineer is but crudely outlined. Far better specifications can be drawn by those more expert in the educational process. But let there be no doubt of the pressing need for a new outlook, a new training, and a new effectiveness.

The usefulness, the validity, of the profession to which we belong and the society which we have built is in question in high places. The issue of the future hangs in the balance. Shall our industrial civilization be encouraged to slough off those poisonous growths which impede its useful offices, or shall it hastily be discarded for untried forms of social organization which can by no possibility offer the same hopeful measure of material goods, ministering to human values?

The issue lies with our own prompt and wise action, and with the training and devotion of those who are to take our places.

---

[2] As examples of rugged heresies I would suggest the belief in the "commodity dollar" and the current enthusiasm for an economy of planned details.

First Annual Report of ENGINEERS' COUNCIL *for* PROFESSIONAL DEVELOPMENT

DURING its first year, the Engineers' Council for Professional Development perfected its organization and made far-reaching recommendations including (1) a program for accrediting engineering schools, (2) a minimum definition of the engineer, and (3) a suggested scheme looking to greater uniformity in the grades of membership in the professional societies. These recommendations and other matters of policy were agreed upon at the first annual meeting of the Council held in the Engineering Societies Building, New York, N. Y., on the afternoon of October 10, 1933.

The afternoon business session was followed by a dinner at the Engineers' Club which was attended by members of E.C.P.D. and by members of the boards of the participating societies and certain important committees of those societies. Following the dinner were addresses by Dr. Franklin J. Keller, director of the National Occupational Conference, Dean Dexter S. Kimball, Dr. Gano Dunn, Dr. D. B. Steinman, and Dr. J. V. N. Dorr. Dr. C. F. Hirshfeld, chairman, E.C.P.D., presided at the session.

ORGANIZATION AND OBJECTIVES

The Engineers' Council for Professional Development, a new agency of the engineering profession, was brought into being in October, 1932, by joint authorization of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

The Council consists of 21 members, three from each of the participating bodies, from whom a chairman is elected, and a secretary, who need not be one of the representatives. Its purpose is the enhancement of the professional status of the engineer. To this end, it aims to coordinate and promote efforts and aspirations directed toward the higher professional standards of education and practise, greater solidarity of the profession, and greater effectiveness in dealing with technical, social, and economic problems. Its immediate objective is the development of a system whereby the progress of the young engineer toward professional standing can be recognized by the public, by the profession, and by the man himself through the development of technical and other qualifications which will enable him to meet minimum professional standards.

E.C.P.D. functions by studying questions within the range of its objectives, and making recommendations from time to time to the governing boards of the participating societies as to procedures that are considered of value in promoting such objectives. It will administer only such procedures as have been approved by the boards of the participating societies and assigned to it.

The first annual meeting, October 10, 1933, was given over to the hearing of the reports and recommendations of four standing committees previously appointed to consider certain specific fields within the objectives of E.C.P.D. and to prepare recommendations thereon. The recommendations are reported in what follows:

STUDENT SELECTION AND GUIDANCE

The function of the Committee on Student Selection and Guidance is to report to E.C.P.D. schemes for the educational and vocational orientation of young men with respect to the characteristics of an engineering education and the responsibilities and opportunities of engineers, in order that only those who have the high qualities, aptitude, and capacity required to obtain intellectual satisfaction therefrom may seek entrance to such courses.

The report of this committee was presented by Dean R. L. Sackett, chairman. It emphasizes the pronounced need for occupational information about engineering in terms and forms which appeal to the immature and inexperienced student. It includes the progress report of a subcommittee which made a study of the literature available as a first step in determining the composition, content, and purpose of a competent guide to the youthful inquirer who desires to know what engineering is and the usual path to achievement in that profession and to those related activities to which engineers are called. Further plans of the committee include studies of (1) experiences with occupational guidance by local groups of engineers, (2) guidance camps, (3) aptitude tests, and (4) cooperation with the National Occupational Conference, the Boy Scouts of America, and with teachers' colleges to encourage the latter to guidance instruction for teachers of mathematics and science, those usually consulted by boys considering an engineering career.

The following statement of objectives, approved by E.C.P.D., was presented in the report:

(1) To recommend sources of information for promising or interested high-school or preparatory students, their parents, teachers, and counselors, describing the qualities and aptitudes which contribute to the successful pursuit of an engineering education and the derivation of intellectual satisfaction therefrom, the quality and quantity of the major subjects pursued in college, the technical positions normally occupied by engineering graduates, the supervisory and executive positions into which they may progress, the value of a technical education as a preparation for industrial and business pursuits, and the activities and responsibilities of the professional engineer.

(2) If satisfactory occupational literature is not available such material should be prepared by revision or compilation after consultation with the National Occupational Conference and other sources of advice.

COMMITTEE ON ENGINEERING SCHOOLS

The duties of the Committee on Engineering Schools are to report to E.C.P.D. means for bringing about cooperation be-

tween the engineering profession and the engineering schools. As a first step in its activity, the committee has the duty of reporting to the Council criteria for colleges of engineering which will insure to their graduates a sound educational foundation for the practise of engineering.

The report of the committee, prepared under the chairmanship of Dr. Karl T. Compton, was presented by Prof. H. P. Hammond. The committee recommended (1) that the Engineers' Council for Professional Development undertake a program of accrediting the curricula of the various schools of engineering which are deserving of approval by the Council as representing sound and adequate instruction in various professional fields of engineering, and (2) that the basis for accrediting colleges which appears in the report be approved by E.C.P.D. as representing the basic principles which should underlie such a program of accrediting.

In presenting these recommendations the committee pointed out that some method of accrediting engineering schools is required by force of laws governing the licensing of engineers in a majority of the states. In order that accrediting may be done uniformly, consistent with the high ideals of the engineering profession and in such a manner as to be a stimulus to the best development of engineering education rather than a deterrent to future progress through codification of certain present standards, the professional engineering societies should be prepared to administer a plan of accrediting engineering schools. The committee suggests the following principles as the basis for such a plan:

(1) Absolute minimum standards of the educational process are to be avoided as likely to fetter future progress.

(2) Information on important aspects of organization, administration, curricula, and standards of each school is to be assembled, the institution is to be investigated personally by a committee, and final action is to be taken by E.C.P.D. after consideration of all aspects of the situation. Because of the variety of types of engineering training and the specialized character of many schools, accrediting is to be on the basis of six major curricula and not on the basis of the school as a whole. Provision is made, however, for consideration of other curricula than these six. It is hoped that the accredited list to be prepared on this basis may be uniformly adopted, thus relieving societies and states of the necessity of duplicating individual action and relieving schools of the necessity of submitting to numerous examinations and questionnaires.

The Council voted to approve the recommendations of this committee and to recommend to the participating bodies that E.C.P.D. be set up as an accrediting agency for schools of engineering. This recommendation is to be transmitted to the participating bodies when E.C.P.D. has completed the scheme of financing such an accrediting agency.

COMMITTEE ON PROFESSIONAL TRAINING

The duties of the Committee on Professional Training are to report to E.C.P.D. plans for the further personal and professional development of young engineering graduates and young men who are entering the profession without formal scholastic training.

The report of the committee was presented by Robert I. Rees, chairman. It reported progress as follows:

(1) A survey of junior members of engineering societies to find, among other things, some indication of plans for self-development.

(2) The preparation of a personal-analysis blank to assist the individual in his program of self-development.

(3) Surveys of educational facilities in areas of concentration of junior members.

(4) A study of the basic objectives for future independent reading by junior members.

(5) Preparation of a bulletin explaining what experience and further intellectual development are demanded by criteria to be set forth by the Committee on Professional Recognition.

(6) Development of procedures for participation by joint subsidiary organizations of participating bodies in different localities.

The Council approved this report and requested the committee to proceed along the lines indicated therein.

COMMITTEE ON PROFESSIONAL RECOGNITION

The Committee on Professional Recognition is charged with the duty of reporting to E.C.P.D. methods whereby engineers who have met suitable standards may receive corresponding professional recognition. The report of the committee, prepared under the chairmanship of Conrad N. Lauer, was presented by Dean J. W. Barker. Upon recommendation of the committee, E.C.P.D. approved the following policy as a guide fulfilling the committee's purpose:

The profession should establish as the goal of attainment, a series of qualifications for which the young man, whether graduate or non-graduate, may successfully strive continuously from the time he enters upon an engineering career. This goal of attainment, embodied in a certificate, equivalent to the professional degree and having a value recognizable as adequate to entitle the holder to licensing or registration in a state, should be based upon the following features:

(*a*) Certification should be earned, and not granted as a mark of honor.

(*b*) The code of educational qualifications should be more advanced than graduation from college, yet attainable by both college and non-college men.

(*c*) The attainments should be tested individually by examination (written and oral) or the equivalent and not gaged by personal estimates and testimonials alone.

(*d*) Educational qualifications should comprise scientific, technical, economic, and civic knowledge of a mature order.

(*e*) The code of experience qualifications should normally make the age of certification fall between 25 and 30.

(*f*) The ultimate certification into the profession should be the objective to which both the colleges and the professional societies should exert their influence. To this end the colleges should be encouraged to aid by granting the professional degree to those who have been thus certified.

(*g*) The certificate into the profession should be the means by which the state registration boards would, with confidence, recognize those essentials which they observe as requisite for the registration of engineers.

(*h*) And, similarly, the certificate into the profession should be prima facie evidence of technical proficiency for admission into the corporate membership of the societies.

By such a progressive educational program involving selection of proper material, its supervised education, intimate contact with the profession during the apprenticeship stage, and the attainment of definite specified educational requirements with concurrent recognition by professional societies, educational institutions, and state laws, it is believed that an identity would be attained by which those who have not developed experience and maturity of engineering judgment would be recognized as assistants in the engineering field, and those who have attained engineering maturity would have an identity universally recognized by the profession itself and the public at large. It is believed that this definition of the engineering profession will be of immeasurable benefit.

The committee presented the results of an extensive study of the various requirements for recognition as an engineer included in (1) the grades of membership of the various engineer-

ing societies, (2) the model law for registering and licensing, and (3) the granting of degrees by engineering schools with the view that the first step that the engineering profession must take to secure proper recognition is agreement on the minimum requirements. The committee recommended the following minimum definition which was approved by E.C.P.D., which voted to transmit it to the participating bodies for their discussion and approval:

The minimum qualifications for an engineer are:

(*a*) Graduation from an approved course in engineering of four years or more in an approved school or college; a specific record of an additional four years or more of active practise in engineering work of a character satisfactory to the examining body (the examining body, in its discretion, may give credit for graduate study in counting years of active practise); and the successful passing of a written and oral examination covering technical, economic, and cultural subjects, and designed to establish the applicant's ability to be placed in responsible charge of engineering work and to render him a valuable member of society; or alternatively

(*b*) Eight years or more of active practise in engineering work of a character satisfactory to the examining body, and the passing of written and oral examinations designed to show knowledge and skill approximating that attained through graduation from an approved engineering course, and also examinations written and oral covering technical, economic, and cultural subjects designed to establish the applicant's ability to be placed in responsible charge of engineering work and to render him a valuable member of society.

In accord with the view that the grades of membership in the various societies should reasonably conform to this minimum standard, the committee presented the following designations and minimum specifications which were approved by E.C.P.D. for recommendation to the participating bodies for adoption, with the stipulation that they are not intended to exclude the affiliation of other persons with any constituent society in a capacity other than the grades of membership indicated:

Student Member. A person matriculated in an approved school or pursuing studies in accord with the program of the Committee on Professional Training.

Junior Member. A graduate of an approved school or one who has passed equivalent written and oral examinations.

Member. The full-fledged engineer, that is, the engineer who has passed the requirements in the minimum definition of an engineer.

The Committee on Professional Recognition is engaged in a further study of a scheme of testing the requirements for the full-fledged engineer, appreciating fully that the method of measuring achievement of the qualifications in the minimum definition of the engineer is of greater importance than the qualifications themselves.

PERSONNEL AND OFFICERS

The complete personnel of E.C.P.D. and its standing committees appears in its printed annual report. At the meeting on October 10, 1933, permanent officers were elected for the year ending October, 1934, as follows: Executive Committee: J. Vipond Davies, Am.Soc.C.E.; Donald F. Irvin, A.I.M.E.; William E. Wickenden, A.S.M.E.; Charles F. Scott, A.I.E.E.; H. C. Parmelee, A.I.Ch.E.; Robert I. Rees, S.P.E.E.; David B. Steinman, N.C.S.B.E.E.; C. F. Hirshfeld, chairman; and C. E. Davies, secretary.

HISTORY OF ORGANIZATION

A Conference on Certification made up of representatives of the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners, on April 14, 1932, approved a "Plan for Joint Action" which proposed the establishment of the Engineers' Council for Professional Development. Six of the seven participating bodies having ratified the "Plan for Joint Action," a temporary organization of the Engineers' Council for Professional Development was formed on October 3, 1932. The seventh body ratified on October 21, 1932.

The personnel of the interim executive committee was as follows: J. Vipond Davies, Donald F. Irvin, William E. Wickenden, Charles F. Scott, H. C. Parmelee, R. I. Rees, D. B. Steinman, with C. F. Hirshfeld, chairman *ex officio*, and C. E. Davies, secretary. The organization of four standing committees to carry on the program embodied in the "Plan for Joint Action" was completed in May, 1933, and the committees proceeded with the preparation of their reports.

The Charter and Rules of Procedure, which are published with the annual report, were completed on March 13, 1933, and were referred to the governing bodies of the participating societies for ratification. Six bodies,[1] Am.Soc.C.E., A.S.M.E., A.I.E.E., A.I.Ch.E., S.P.E.E. and N.C.S.B.E.E. have approved the Charter and Rules of Procedure.

C. F. HIRSHFELD, *Chairman*
C. E. DAVIES, *Secretary*

[1] A.I.M.E. ratified the Charter and Rules on Oct. 20, 1933.

Ernestine Shepard

LESSONS *of the* STRETCHOUT

A Preliminary Report of a Study of Some Human Problems in the Management of Technological Change

By ELLIOTT DUNLAP SMITH[1]

TECHNOLOGICAL ADVANCE is not only a generic change which has painfully disturbed the equilibrium of supply and demand; it also consists of a multitude of individual technological changes in individual factories, each of which has created difficult managerial and human-relations problems.

Several years ago at the Institute of Human Relations at Yale, we undertook to make a start in the systematic study of these problems. To simplify our all too complex task, we decided to confine our study to one technological change at a time. To make our investigations representative, we sought to include cases that typified the main variations in both method and result. We then sent men with managerial experience to make a careful study of each of the score of cases we had time to cover. To make sure to disclose all factors affecting the management of human relations, we investigated at each factory all aspects of the handling of the change, from finance to engineering and from merchandising to personnel. Sometimes we were in contact with a mill for several years.

A detailed case report of each mill was written. To make the cases comparable in time, we divided what happened at each mill into four periods—preliminary, preparatory, installation, and stabilization. Where strikes had occurred, we added a post-strike period in which to indicate the changes resulting from the strike. To make the cases more comparable as to both measures and results, we also divided them into the main managerial functions, such as financial, technical, and labor management. Thus, in reviewing our case reports, we could follow the course of development of any function through all the periods, or the development of all functions in any one period. Of especial importance was the fact that by thus fitting each case to this common structure of periods and functions, in studying the developments of one function in one period in one mill, we could readily compare it with the developments of the same function and in the same period in the other mills, and could also see these particular developments in relation to the structure of the change as a whole.

Since the interrelation of forces was too complex to permit isolating reliable statistical constants and the number of cases was so small, we could not employ the customary statistical techniques. Still, to a considerable extent, the results of these case studies could be transferred to charts subdivided into the same periods and functions as the full reports. The character of these charts is indicated by Fig. 1. While partial and inadequate in themselves, by making the common elements and structure graphic, these charts united with the period-function arrangement in assisting in comparison of the cases.

Then we studied these cases and charts. We got experts in the major human and social sciences to help us and to point out sources of error and implications significant from the standpoint of their field. That is where we are now. It is an unfinished and crude piece of work. Its principal value so far lies in its exploration of a method of study that gives promise of being adapted to the investigation of the human problems of technological change. Our material is not yet sufficiently extensive to justify drawing positive conclusions. But even in midstream some implications, though tentative, stand out clearly enough to be worth mentioning.[2]

THE TECHNOLOGICAL CHANGE

To make clear the character of our results, it is essential to describe briefly the technological change we selected as the first to be studied—the so-called "cotton textile stretchout." Superficially, this was not a technological advance at all, but what its name implied—a stretching out of the weaver to tend more and more automatic looms. Fundamentally, however, it was an important technological advance in industrial engineering.

Automatic looms were in general use and were being used with a high degree of mechanical efficiency. The output per loom was high. Like efficiency, however, had not been developed in the use of weave-room labor. To attain this labor efficiency by scientifically improving working conditions and developing the techniques of automatic weaving was the purpose of the mills which originated the movement.

On the one hand they undertook, through systematic study, to integrate all the functions of the mill to meet the needs of the looms and their weavers. The cotton purchased, the preparatory processes, the type of products, the method of sale, as well as the conditions and procedures of the weave shed were all systematically studied in regard to their effect upon the work of the weaver.

On the other hand, these mills undertook to functionalize weaving labor in much the same manner that Taylor developed the functionalization of management. Hitherto, labor specialization in textiles had consisted of a subdivision of textile processes into subprocesses, each of which was assigned to a separate worker. Occasionally, a separable part of a single process, such as the putting in of the new warp, had been singled out and given to a specialized worker. But in the "stretchout" the entire process of weaving was systematically subdivided into functions on the basis of the types of skill required, and these functions were assigned to different workers who together performed the single task of operating the looms. Thus, for example, feeding the looms and repairing major operating breaks were separated from loom operating, and each was given to separate "hands." So, also, were taking out the finished cloth, cleaning, and so on, through the various functions.

These two automatic weaving techniques—the integration

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Contributed by the Management Division and presented at the Annual Meeting, New York, N. Y., December 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[2] In this short paper, unfortunately, it is not possible to cite the instances from which conclusions are drawn. Yet it is in the suggestive value of these particular experiences that the greatest interest of these studies lies, and without them the conclusions are lifeless and pallid. These particulars will be fully given in a book later to be published.

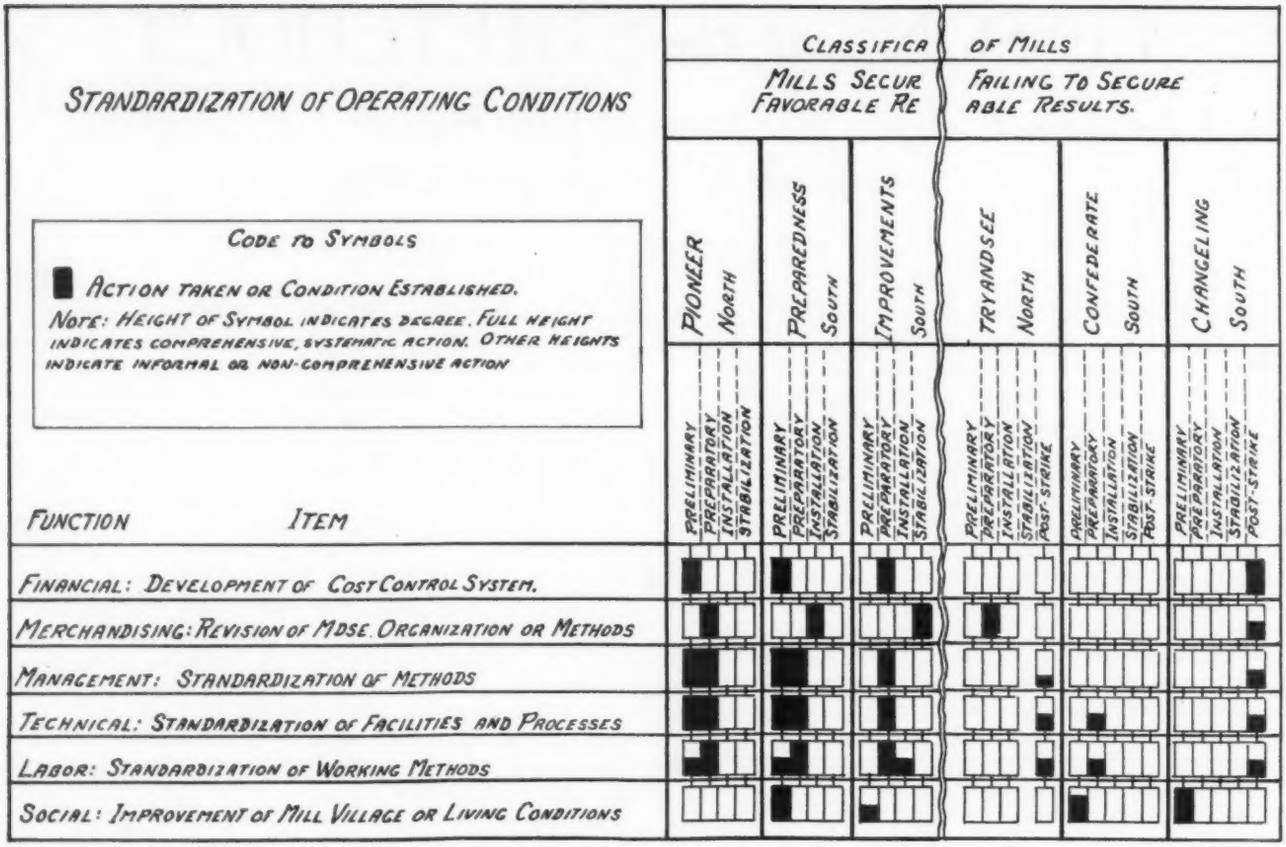


FIG. 1 FRAGMENT OF FUNCTION-PERIOD CHART

(Illustrating a graphical method of representing comparatively the extent of action of the individual mills in the major managerial functions during each of the periods. For the sake of simplicity this example of our charts has been confined to the single item of "standardization of conditions.")

of all functions of the mill in relation to the needs of the weaver, and the functionalization of the work of weaving—were by no means universally understood or fully carried out. They constituted, however, an important technological advance which, because it occurred in an important industry, because it was widespread, because there was such wide diversity in method of introduction and in results, because it was still in process of introduction, and because it related directly to the use of labor, was selected as the initial technological change for investigation.

A MAJOR TECHNOLOGICAL CHANGE IS A MAJOR INDUSTRIAL DISTURBANCE

As one reads the cases, certain major conclusions common to all cases are clearly evidenced. In the first place, if the development of automatic weaving is at all typical of other technological developments, the results of its introduction into the cotton industry give strong evidence that in drastic technological change the problems and risks of the concern and of its workers are serious. In all of the mills investigated substantial demotion occurred. In many, serious unemployment was precipitated. In all, the weaver, while concentrating more than before upon skilled work, was reduced from a skilled craftsman who made his own decisions to a routine manipulator. Moreover, the looms paced the worker, and the number of looms per weaver was drastically increased. Although the strain on the worker depends not so much on the number of looms assigned as upon methods, working conditions, and similar factors, these factors were dependent upon skilled management. Far more than in ordinary times, when conditions were stable, was the task of management difficult. Far more than in normal times the workers and the company were dependent upon management for their well-being.

Since the demand for labor and the requirement of skill were both reduced by the change, the worker was at a disadvantage in protecting himself against the consequences of mismanagement at the time when mismanagement was most likely and most disastrous. Though many mills, by skilled management, both obviated most human distress and strengthened their organizations, many did not. When management failed, the distress was so great that even where there were no unions and no union organizers, unorganized workers without union agitation often organized and struck. When management failed, the effect upon the mill was so serious that bankruptcy was not an unknown consequence. Apparently, the birth of a new labor technique, like childbirth, requires both skilled management and skilled after-care, and at best cannot be brought about without considerable disturbance to the organism.

LABOR SAVING BY METHOD AND BY MECHANISM

In every case studied but one, the introduction of scientific automatic weaving techniques or their abortion as a mere stretchout of loom assignments followed long after the automatic looms had been bought by the mill. This separation of the introduction of labor-saving methods from the introduction of labor-saving mechanism seriously increased the danger of mismanagement.

With the introduction of labor-saving *machinery*, attention is concentrated upon saving labor by getting more from the machines. With the introduction of labor-saving *methods* as our investigations indicated, the fact that attention is concentrated upon getting more from the worker makes it all too easy to fail to maintain the difficult distinction between reducing costs by labor saving and doing so by labor driving.

With labor-saving machinery, moreover, even highly complex and delicate interrelations can be built in, and, as the electric sweeper or the dial telephone have demonstrated, can be made so nearly foolproof as to be capable of operation by the run of men. With labor-saving methods, interrelations and delicate adjustments cannot be built in. Each increase in technological refinement renders more difficult the adjustments which management must maintain. No device has yet been contrived which renders the management of a department foolproof or removes the necessity for great foresight and skill in plowing up old methods and implanting new.

Besides, the fact that the introduction of the new methods did not involve substantial capital outlay at the time removed an important safeguard of sound management.[3] Since no large sums were required at the outset to buy machines and since the necessity of future expense was obscure, the chief administrative bodies, in a majority of our cases, approved of and even encouraged the installation of the new methods without thorough investigation and with a lightness of heart quite unlike the care with which they scrutinized proposals for even minor expenditures. Within the individual mill, since the equipment was all on hand, instead of the piecemeal introduction and the consequent feeling of the way, customary with new equipment, the change was often explosively abrupt. In the industry as a whole, while the introduction of the automatic looms had been gradual, under the pressure of adversity and without the retarding influence of inescapable initial investment, the stretchout rapidly became epidemic. Thus, because of its financial as well as its technical aspects, labor saving by methods involves greater and more difficult human problems than labor saving by mechanism.

FORCED VS. PLANNED ACTION

The quarter century which elapsed between the development of the automatic loom and the first application of scientific study to its use was terminated by the pioneer work of a few mills urged forward by the incentive to economy provided by an exceptionally serious depression. Even after the new automatic weaving techniques had been devised and demonstrated, rarely did any concern undertake the change until whipped to it by its own acute financial necessities. The price of this delay was high.

In the first place, it divorced the introduction of these labor-saving methods from steadying association with the introduction of the labor-saving machines to the use of which they related. Besides, it concentrated into a single change many steps of technological progress that would otherwise have been spread over years. Instead of making at one time each minor development, such as the division of labor between weavers and battery hands, and then later following it by another, such as the introduction of a standard loom patrol, the whole complex of changes in conditions, methods, and work assignments was concentrated into one. With so much changing at one time, both worker and plant had much at stake, and the cost of error was high. With so many changes tangled into one, far greater scientific foresight was needed to think the problem through and far higher managerial skill required to keep it in hand. By waiting until driven by necessity, instead of *constantly* using scientific means to improve methods, the opportunity to learn from experience in "short easy lessons" and at small unit expense was lost.

Moreover, twenty years without substantial change provided twenty years of stagnation for both management and weavers. By the time the change came, both were so rutted in the old ways that it was hard to learn the new. Especially the older workers—weavers, overseers, and superintendents alike—had difficulty in making the change. The age level dropped and middle-age obsolescence increased.[4]

More serious was the fact that at the time when most stretchouts were made the industry was in economic distress. The demand for cotton textiles was not only unprecedentedly low but unprecedentedly fickle. Old products were disappearing and new ones being developed. The mills, when making the change, rarely knew from month to month whether or not they would have work to do or what that work would be. The market was so depressed that each unit of labor saved meant one more worker unemployed. The worker's funds were low and their families in no position to help them. Displacement that in normal times would have caused little distress caused serious hardship. Delay had brought the change into a time when the worker was especially ill equipped to meet it.

Of even more serious consequence, however, was the fact that the typical mill at the time it made the change had its back so closely against the wall that there was rarely adequate cash or credit to finance scientific study and preparation. Often there was not time. With losses staring them in the face, what the directors demanded above all else was quick economies. On a sinking ship there is little concern with long-range plans. Small wonder that many mills grasped at the quick possibilities of expansion of the workers' duties, while neglecting the slow, expensive work of improving the conditions and methods by which only could the assignment of increased numbers of looms be prevented from resulting in excessive loads.

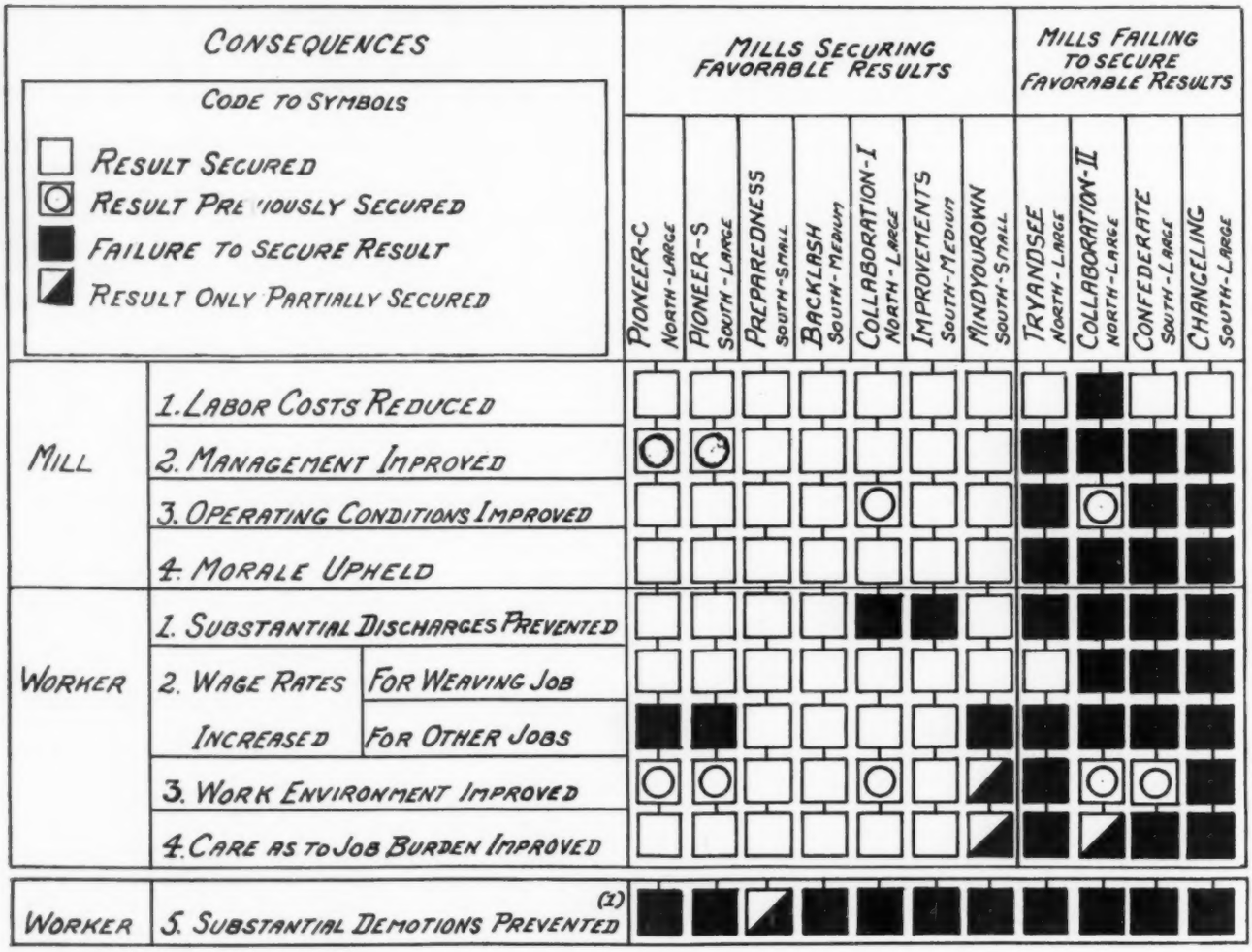
Failure to carry scientific development forward until driven to it by the lash of necessity thus greatly multiplied the seriousness of the human consequences of the technological change. To the removal of the restraints that would otherwise have been imposed by the necessity of large initial expenditure for equipment, it added the difficulties of making an abrupt concentrated change after a long period of stagnation at a time when both the mill and its workers were handicapped by economic stringency.

THE IMPORTANCE OF COMPREHENSIVE ADAPTATION

In spite of these difficulties, many mills, through skilled management, accomplished the change with economic advantage and with almost complete absence of social harm. When one compares the work of these mills with those where the results were less favorable, one cannot but be struck by the extent to which social and company results went hand in hand, and also by the extent to which results were either favorable or unfavorable throughout. Apparently, with so violent a disturbance as a major technological change, results rarely stop halfway. Nor did conditions such as size or location of the mill, or the character of its product or of its labor, alter

[3] Ultimate expense, however, was by no means insignificant, mills often expending hundreds of thousands of dollars in the introduction of the new techniques.

[4] The effect of a long period without change followed by a spasm of progress, upon the whole problem of middle-age obsolescence of industrial executives and employees is fully discussed in a pamphlet entitled "What Are the Psychological Factors of Obsolescence in Middle Age?" by Elliott Dunlap Smith, published by American Management Association as Personnel Series No. 9, and in "Handbook on Business Administration," McGraw-Hill, 1930.



[1] Since an invariable result, demotions are shown separately.

FIG. 2 OPERATING CONSEQUENCES OF THE INTRODUCTION OF THE STRETCHOUT SYSTEM

this. In spite of wide variations in these conditions, the eleven cases of which our studies are now sufficiently complete to report on, as indicated in Fig. 2, divide clearly on the lines of those that got generally good operating results and those that got generally bad. This makes it possible to group the successful and unsuccessful mills, and to see whether there are any characteristic differences in the measures they followed.[5]

In nearly every successful mill, the change as a whole was carefully thought through. As little as possible was left to trial and error. It was realized that the whole industrial structure was being put under strain, and every aspect of the change, financial, merchandising, managerial and human relations, as well as technical and operating, was systematically worked out. When one reads the work of the most successful mills one cannot but be struck by the extensiveness of the ramifications of the problem and by the completeness of their adjustments of other functions to what was apparently solely a technological change.

The unsuccessful mills, on the contrary, trusted to practical knowledge intuitively applied. While this had worked when the change involved was small and the main problem was the maintenance of the *status quo*, it proved inadequate to meet the needs of a major change where the job was not to maintain, but thoroughly to reconstruct, the *status quo*. Too many new factors were involved to be kept in hand without systematic planning. Usually, only the most apparent adjustments were made, and the new technique inserted, not absorbed. Such "spotty" management was fatal, for adjustment in one field could not carry the whole burden of a change which, in spite of its technological nature, affected all. Poor labor management, poor technical work, poor merchandising were apparently each enough to "upset the entire apple cart" and bring untoward consequences in other fields tumbling in its train. Only a well-rounded handling was adequate to support success.[6]

Especially important, and especially likely to be overlooked even when consultants were employed, was the personnel function. In cotton mills, where each superintendent and even

[5] Possibly, this grouping was somewhat due to the mills selected. Most of them were chosen because they were considered significant cases. Hence, they were likely to be mills where rather striking consequences had occurred. Still, the validity for comparison of methods, of the division into successful and unsuccessful mills is not thereby impaired.

[6] The undertaking and timing of typical measures of adjustment by the principal mills studied are shown in Fig. 3. In this chart the functional division of material is abbreviated in order to bring out the individual measures more clearly. Besides, the periods are indicated horizontally instead of vertically in order to emphasize the differences in the timing of the same measures by the several mills.

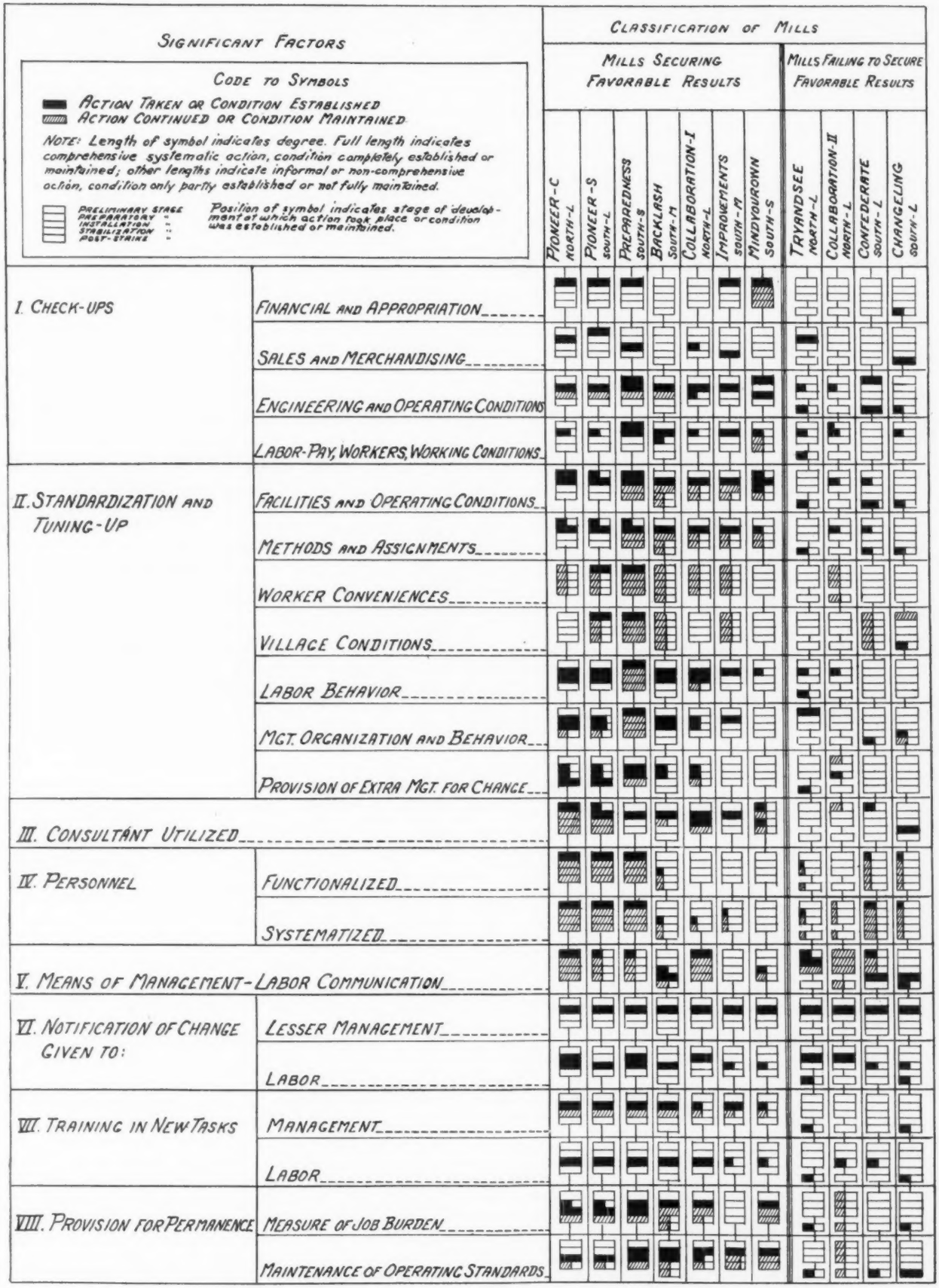


FIG. 3 DISTRIBUTION AND TIMING OF TYPICAL MEASURES

each overseer handles the entire problem of his mill or his room, personnel management has usually been just something the operating executive "took in his stride." He has always "handled his help himself" without any formal procedure and has "gotten away with it." The men at the top, as the agent of one of our mills put it, "leave all that to the superintendent and overseers. Then I don't have to worry about it. I let them hire or fire such workers as they choose, but I hold them strictly responsible for production." Hence, unless some special provision was made, this function was left without systematic attention.

With so complex a problem as the stretchout, sins of omission were more common and more fatal than sins of commission. No implication arises more clearly from a study of our cases than the necessity of systematic, comprehensive planning if a technological change of this sort is to escape disaster from the failure to consider and throw some apparently remote but actually involved switch.

PREPARATION AND STABILIZATION

It was not enough, however, to cover the entire problem. It was essential to take each measure at the right time, and especially not to let technical developments get ahead of the capacity of developments in other functions to support them. One aspect of management that especially differentiated successful from unsuccessful mills was the handling of the period before and the period after the actual installation.

In the preparatory work two steps were especially disadvantageous to overlook. The first was a careful survey and tuning up of the *status quo* in relation to the new requirements *before* the methods and assignments were actually changed. No one of the mills which succeeded omitted this step—no one of the less successful mills fully included it in the preparatory period.[7]

A second measure of outstanding importance in the preparatory period was the careful adjustment of the new techniques, the standards of production, and the work assignments to the conditions of the individual mill and the needs of its employees. Measures could never safely be transplanted without adaptation, for what was good sauce for the "goose" mill often proved fatal for the "gander." With so fundamental a change, without careful and skilled time studies and similar objective measurements, the setting of new standards and loom assignments was rarely successfully done. Even procedures carefully worked out in the laboratory of the individual mill, as well as those transplanted by consultants, needed checking by careful work-room trial.[8]

These two measures are but typical of the many which must be taken preparatory to installation. With a major technological change it is dangerous to launch the change trusting to the correction of haphazard preparation by measures learned from experience after the change is in full swing. For not only is such complex experience a difficult teacher to learn from, but the immediate price of error is high and the process of reconstruction far more costly and difficult than proper preparation.

The stabilization period was also a critical one; for unless the new conditions on which the job assignments were based were "pegged in," they slipped back after the close attention, that goes so far in making new measures succeed so long as they are new, faded into the lessened attention and interest in a "fait" not merely "accompli" but a bit "passé." Especially when consultants were employed in the installation, the problem of follow-through tended to be the point of difficulty. Even when their procedures were understood by the operating management—which was by no means universal—the operating executives of the old school rarely had sufficiently sustained interest in the plans of the consultants of the new to cause them to take punctilious care in executing these plans after the consultants left or even to recognize the necessity for "all the added detail." Hence, unless systematic provision was made both for the maintaining and for the checking of the new conditions, back-sliding generally occurred.[9] Because of this, strikes were as common well on in the post-stretchout period as in the period of change itself.

INDUSTRIAL-RELATIONS MANAGEMENT DURING TECHNOLOGICAL CHANGE

Throughout the industry South and North, the stretchout gave rise to bitter and often desperate strikes. And yet, both at the start and throughout, mill after mill accomplished the change without serious labor unrest. Yet in all but one of the cases which we have studied, good or bad, unless an adequate channel, formal or informal, for the formulation and expression of employee point of view existed or was provided, the workers themselves provided one by unionization.[10] If some means existed that was adequate, the form was unimportant; if it did not, the workers provided their own, and the elaboration and pretense of any preexisting form was of no consequence except when its pretense proved a source of irritation.

The provision of channels of communication, however, did not at all solve the employee-management relations problem. Like the automatic weaving techniques themselves, such channels were easier to establish than to maintain. It took skilled leadership to use them well. Besides, to establish an effective channel of communication between employees and management exposed management to the light of clearer employee understanding, and thus led to unrest unless the management procedure and attitude were capable of being subjected to employee observation without loss of employee respect.

The whole problem of industrial relations was also greatly affected by the preexisting character of these relations. Such an upheaval as the stretchout operated upon employee relations much as a period of depression does upon a company's relationships with its banks. Where the company from consistent fair dealing in the past had accumulated a considerable capital of good-will, this served it in good stead in the time of strain. The typical initial response of the employees in such mills to the advent of the stretchout was one of confidence that the management knew what it was doing and was going to play fair. Even if the stretchout had an unsavory reputation in the community, even if the new loom assignments seemed incredibly large, there was considerable willingness "to wait and see." Judging from our cases, good-will based on years of considerate and fair but also firm management is a vital asset for any mill to carry into the stress of technological change.

Still, good-will, like credit, or even a cash balance, was

[7] The action taken by the different mills in surveying conditions in regard to each managerial function is indicated graphically in Fig 4. This chart is devised both to emphasize the period in which action was taken and to show accumulatively the thoroughness with which all functions were covered in this regard. For simplicity only three successful and three unsuccessful mills have been plotted, but these mills are typical of the others. Note the completeness with which the three upper (successful) mills checked all functions prior to the installation period, and the spottiness of the preparatory checking by the three lower (unsuccessful) mills. The post-strike rechecking by these mills is interesting. The "Pioneer Mill" could not check social conditions as it owned neither mill village nor company houses. The extent of tuning up as distinct from checking is shown in Fig. 3.

[8] See item II, Fig. 3, for extent to which such standardization was accomplished in the preparatory periods by the different mills.

[9] See item VIII, Fig. 3, for provision for permanence made by the several mills. Note especially the extent to which these were provided in the post-strike period by the unsuccessful mills.

[10] See item V, Fig. 3.

easy to squander. While it provided the attitude for understanding, it could not provide the understanding itself. Nor could the mere existence of effective channels do so. The actual safeguarding of employee well-being had to be there and be evidenced in ways the employee could understand, or the whole structure crumbled to wormwood and ashes.

SCIENTIFIC METHODS REQUIRE SCIENTIFIC MANAGEMENT

The strain upon management nowhere ended with the installation of the new techniques. To a large extent the introductory strain could be and was successfully met by the utilization of consultants or staff specialists.[11] But the new methods themselves, even after they were fully installed, created managerial problems different from the old.

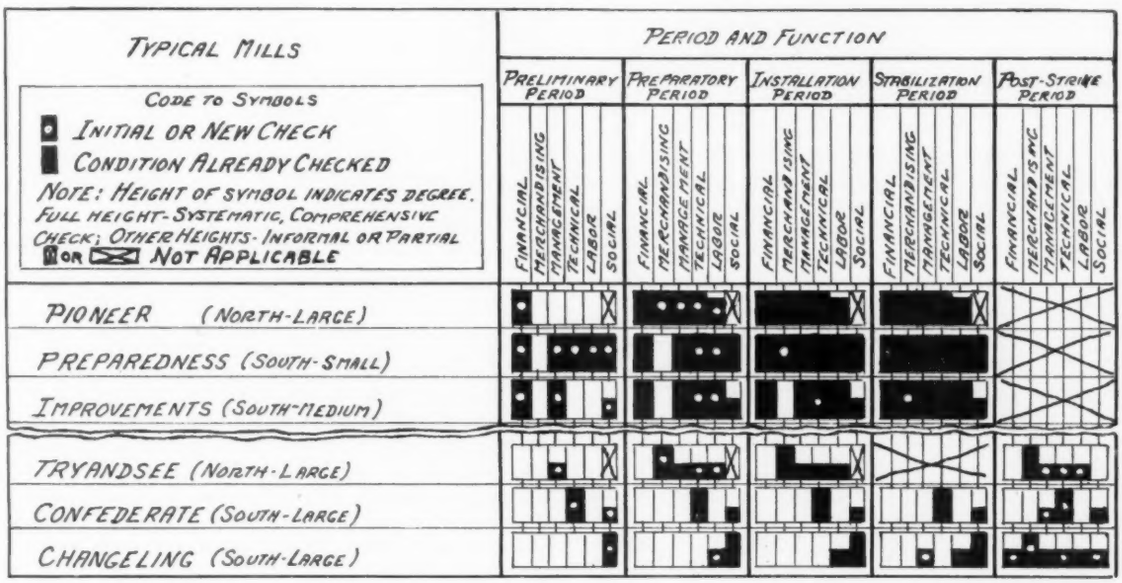


FIG. 4 FRAGMENT OF CUMULATIVE FUNCTION-PERIOD CHART OF CHECKS OR SURVEYS OF CONDITIONS

(Functions checked: Financial—estimate of expense involved; Merchandising—sales, organization, and methods; Management—personnel, organization, and methods; Technical—facilities, processes, materials, etc.; Labor—pay, workers, working conditions; Social—mill-village or living conditions of workers. Top three mills secured favorable results; bottom three failed to secure favorable results.)

In the typical mill, before the change, traditional knowledge and rule-of-thumb ways of control had satisfactorily met the managerial requirements. If an overseer knew his men and knew how to handle any problems of cloth construction and loom operation that arose, all was well.

After the change, the problems were fundamentally different. The very act of narrowing the work of the weaver from the management of his looms to a sequence of skilled manipulations had transferred managerial responsibility to the overseer. The breaking up of weaving into differentiated functions meant that the mill management had to keep these interrelated functions in tune. Since the increased loom assignments were largely based upon precise adjustment of conditions, materials, and preliminary processes, the task of maintaining these more refined conditions also fell upon management. Overseers now had to see that a complex structure of operatives performed with skill and an entirely unwonted precision in quality and timing, narrowly differentiated but closely intermeshed operations.

If a loom battery ran out of bobbins or some adjustment in the loom became defective, it was no longer the weaver's "own hunt" but a failure in management control. A slight irregularity in the yarn was no longer of slight consequence, nor was it up to the weaver "to make the best of it." It required prompt attention from the management. Most different and difficult of all was the fact that since the interweaving of related elements was so taut and so intricate, and since any failure of any element was so likely to produce a difficult tangle, it was no longer enough to correct trouble—it was essential to foresee and prevent it. Corrective management had to be replaced by preventive management and a wholly new managerial technique was required.

Systematic measures of executive control, such as standardized planning, were necessary to keep the more intricate interplay of specialized processes in the balance. Systematic measures of executive control, such as objective records, were necessary to maintain the more refined standards and to detect difficulties before they became serious. Of especial importance was having some major record, upon which management relied, relate directly to what the employee did and understood. To measure such factors as twist, length staple, or humidity were unquestionably valuable aids to maintaining proper working conditions, but they were too remote in their relation to his work to be of much significance to the employee. His main job was correcting loom stoppages, and the record which he regarded, and rightly regarded, as his principal safeguard, was a record of how many loom stops he must repair per hour. Only such a measure reflected the accumulated effect of conditions that, in themselves, might seem trivial to executives, and of conditions that might escape separate record.[12]

The general process of scientific managerial control is too widely understood to merit discussion here. What is important to record is that the refinement of laboring methods called for a parallel refinement in the techniques of executive control,

[11] See Item III, Fig. 3, for the extent to which consultants were utilized.

[12] See "Measure of Job Burden" under item VIII, Fig. 3, for the extent to which systematic records of loom stops were installed.

and that this in turn required a new type of manager—a man who, in addition to being capable of responding to concrete present problems, was also capable both of dealing with abstractions and symbols, and of systematic prevision. These qualities few mill overseers possessed. When a factory considers adopting more refined labor process and organization, it must also consider whether its management can measure up to their demands.

TRAINING OF EXECUTIVES IMPORTANT

Even when executives capable of mastering the new requirements were at hand, to train them was difficult. Every mill, even the least successful, notified their operating executives in advance of the change, but the knowledge of how to carry on so different a managerial process could not be instilled by mere proclamation or even example. Only successful mills supplemented this notice by education.[13] These mills recognized that mastery of such basically new problems of management could only be learned on the job and from experience. This took leadership, time, and a careful feeling of the way. Thus, in a majority of the successful mills, one or two weaving units were shifted over first. This enabled the second hands and overseers to see the problem in a small area where conditions could be readily controlled. Instead of having to dash here and there, trying to solve the multiple difficulties of an entire weave shed recently put on a new basis, they could concentrate on one small unit, and when things went awry, correct the difficulties promptly before they became established as inherent in the new order. The ill effects of any shortcoming were also confined to so few workers that they were unlikely to become a factor in general employee unrest. Most important of all, however, the management could learn the problems of the new situation and how to meet them, step by step, and on a sufficiently small and slow scale, so that they could thoroughly understand them and respond to them.

More refined management records and techniques, however, not only call for a higher quality of man to carry them out, but for more refined management organization. There were, however, no forms of organization at all consistently associated with success or failure. Still, one principle seemed common to most successful mills—the contriving of organization in such a way that the responsibility for long-run policies and their execution, especially as regards industrial relations, was placed in the hands of people who were not caught in the exciting game of winning immediate efficiency from the new order.

Every development in labor specialization made the task of management more complex, every increase in labor assignment based on improved conditions required management control to be more exact. Both required management to be more systematic and to rely more upon objective measurements. All three called for a higher type of manager and for management training. All three also tended to cause the problems of the worker as a human being to become more remote and obscure, and his long-run interests to be lost sight of. To this was added the pressure for immediate results. To meet this situation, a form of organization which differentiated and set apart from these influences the long-run point of view was of importance.

CONCLUSIONS

From so incomplete a study, only suggestions can be drawn. The following conclusions are not merely based on too few instances to be scientifically reliable; they are implications drawn from case studies, and as such are shot through with subjective inferences. They are thus of suggestive value only, and should be appraised by the reader in the light of his own understanding, never taken as objectively established.

A far-reaching change in technological methods is a major disturbance of human relations and may have serious human and social consequences. The human problems of methods change, moreover, are greater than those of the introduction of labor-saving mechanism. The dangers also are far greater if, instead of a series of small changes, an accumulation of lesser developments are concentrated into one abrupt major change. They are greater also if the change occurs in a period of depression. For all these reasons, the human distress and economic failures arising out of technological change will be reduced if scientific study and progress are continuous instead of occurring in such spasms as are prompted by economic adversity.

The dependence of the workers upon the skill of management and upon its interest in their welfare, and the dependence of the company upon the loyalty and cooperation of its workers, are both far greater than in normal times. Hence, in a major technological change, good-will with employees is an asset comparable to good financial credit; and good management must be good personnel management.

GOOD MANAGEMENT MUST BE SYSTEMATIC MANAGEMENT

In so complex a reconstruction as a drastic technological change involves, good management must also be systematic management. All aspects of the change, and the adaptation of all functions of management to it, must be thought through in advance. Just to do intuitively what the present occasion demands is to court failure. Among other things, adequate preparation requires surveying and "tuning up" all functions, not only technical processes, providing more precise techniques of executive control, especially some direct objective measures of employee burden, and making definite provisions for the maintenance of the conditions upon which the new techniques rest.

Methods of management, management personnel, and management organization must also be brought in line. This in turn requires management education and a chance to learn from experience by a sufficiently gradual extension of the change from unit to unit. It also requires contriving a form of organization that will insure that the long-run point of view is not lost sight of in the pressure of immediate contingencies, that the personnel problems do not get overshadowed by the technical, and that the employees have some effective means of understanding the change and expressing their point of view in regard to it.

Above all, a study of the stretchout indicates that what was apparently merely a technological change cast its influence far afield and affected matters as remote as sales policies, methods of management, and mill-village conditions. If such policies, methods, and conditions cannot be brought into line with the proposed technological developments, it is better to wait until they can. For just as with a salient in the battle front, it is dangerous to push the technical salient too far in advance of the general front.

The world today is suffering because our technical skill in production has become so advanced that it is no longer adequately supported by our skill in distributing the potential bounty which our technical skill makes it possible to produce. Similarly, in the individual factory, unless adequate provision is made to support technological advance by equivalent advance in other fields, especially in the management of human beings, such an advance is likely to bring serious human, as well as economic, consequences.

[13] See Fig. 3, items VI and VII.

How WATER FLOWS *in a* PIPE LINE

By CHARLES M. ALLEN[1]

FIG. 1 PENSTOCK AT ALDEN HYDRAULIC LABORATORY, WORCESTER POLYTECHNIC INSTITUTE, SHOWING INJECTION STATIONS

DURING the past few years, many conjectures have been made as to how water actually flows in a pipe line. The assumptions have varied from streamline or parallel flow to the Clemens Herschel idea of watching the path of feathers from a pillow opened in a narrow, windy street.

After many years of investigating and using the salt-velocity method of water measurement in pipe lines, we have come to the conclusion that there is no such thing as streamline flow above critical velocity, and that Mr. Herschel's theory was a very good illustration of how water actually flows. Possibly a better illustration of the picture would be that of a bird's-eye view of a flock of sheep being driven along a country road lined on both sides with good feed. The sheep in the middle will be trotting along, gradually working their way to the side of the road, slowing down in so doing, grabbing a bite to eat, and then, walking with more or less interference, finally getting back into the center, and perhaps the next time getting a bite on the other side of the road. The moving sheep present a slightly convex front as they travel faster in the center of the road and almost come to a stop on the sides. A salt-velocity traverse curve compared to an instantaneous-velocity curve of pipe flow makes the above illustration seem reasonable.

For the past year or more, work has been carried on at the Alden Hydraulic Laboratory for the sole purpose of getting a mental picture as to just how water does flow in a pipe line. This was accomplished by continuously injecting brine through a small tube into a pipe line at a given point upstream from several individual electrodes spaced uniformly across the pipe. As the salt is in solution, where the salt goes the water must go.

DESCRIPTION

For these investigations, the lower end of the 40-in. riveted steel penstock supplying water to the main laboratory was used. See Figs. 1 and 2. At each station two taps were made in the penstock so that two traverses for the injection of the brine could be made. These traverses were on diameters 90 deg apart. In order to determine the amount of spread or dispersion of the brine, 21 individual pairs of electrodes were mounted upon a frame and permanently installed in the penstock, 350 ft below the head gate. The brine injection stations were 5 ft, 11.2 ft, 20 ft, and 45 ft above the electrode station. The penstock is straight for 100 ft above the electrode station and then there occurs a long-radius vertical bend of 7 deg. The horizontal projection is a straight line throughout. Pitometer traverses were made at both upper and lower ends of the 45-ft test section and were found to be identical.

The electrodes were made of galvanized iron screen 3 in. in diameter, of $^1/_4$-in. mesh, separated from each other $^1/_2$ in. These individual pairs of electrodes were mounted on the ends of $^3/_8$-in. square insulating rods, 6 in. upstream from the supporting frame. See Fig. 3. The 21 pairs of electrodes were wired separately to 21 ammeters of $^1/_2$ ampere capacity arranged on a board in a position corresponding to the electrodes in the pipe. See Fig. 4. A 110-volt alternating current was supplied to the circuits. A concentrated salt solution was introduced through a pitot tube $^1/_8$ in. in diameter facing downstream. This tube could be held at any position across the diameter of the pipe. At each station two diameters at right angles to each other were used. Salt solution was introduced through this tube under constant pressure which was in excess of the penstock pressure by about 5 lb per sq in. This excess pressure was necessary to overcome friction loss in the tube and inject the proper amount of brine with approximately the same velocity as that of the passing water.

PROCEDURE

The pitot tube was placed at a definite point on the diameter at one of the stations. The brine under the proper pressure was turned on, and after a sufficient time to allow conditions to become constant, observations were begun. The indications of the ammeters were noted both as to amplitude and intermittency, the latter caused by the cycle of flow in the pipe line. This intermittent indication occurs on the boundary line of the dispersion. Observations of two or three minutes were made at each position in order to cover the cycle of flow. This was done at all stations and on both diameters for three velocities of the water in the penstock. The mean velocities used in the pipe line were 0.6, 2.6, and 4.6 ft per sec.

[1] Professor of Hydraulic Engineering, Worcester Polytechnic Institute, Worcester, Mass. Mem. A.S.M.E.

Contributed by the Hydraulic Division and presented at the Annual Meeting, New York, N. Y., Dec. 4 to 8, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

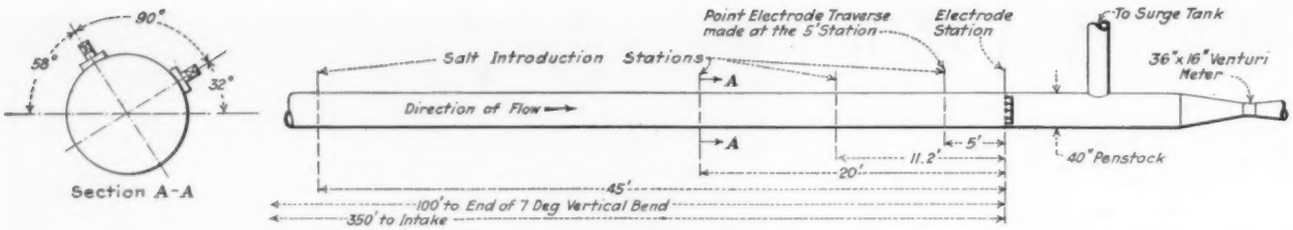


FIG. 2 LAYOUT OF APPARATUS FOR WATER-FLOW STUDY IN 40-IN. PENSTOCK, ALDEN HYDRAULIC LABORATORY

FIG. 3 ARRANGEMENT OF ELECTRODES

TABLE 1 RESULTS OF WATER-FLOW STUDY IN 40-IN. PENSTOCK

Distance from point where salt is introduced to center of pipe, in.	Salt introduced at point 5 ft upstream — Mean pipe velocity, fps 4.6	2.6	0.6	Salt introduced at point 11.2 ft upstream — Mean pipe velocity, fps 4.6	2.6	0.6
19	14.0	13.0	13.0	30.2	32.0	28.0
18	17.5	17.7	15.0	33.0	33.5	27.5
14	22.2	24.5	16.5	42.7	43.7	30.2
8	20.0	21.0	18.0	51.0	49.5	34.5
(Center 0)	15.5	15.5	15.5	50.7	61.5	23.0
Average	17.8	18.7	15.6	41.5	44.0	28.6

	Salt introduced at point 20 ft upstream — Mean pipe velocity, fps 4.6	2.6	0.6	Salt introduced at point 45 ft upstream — Mean pipe velocity, fps 4.6	2.6	0.6
19	61.5	59.7	56.0	85.5	85.7	84.2
10	68.7	75.0	60.7	88.0	87.5	87.5
(Center 0)	68.0	68.5	61.2	78.0	78.0	78.0
Average	66.1	67.7	61.2	83.8	83.7	83.2

(Table shows the percentage of the pipe area affected by the salt solution when the solution is injected at the stations noted with three different water velocities in the penstock. The results are the average values of four diagrams with the injection tube located at points equidistant from the center of the pipe.)

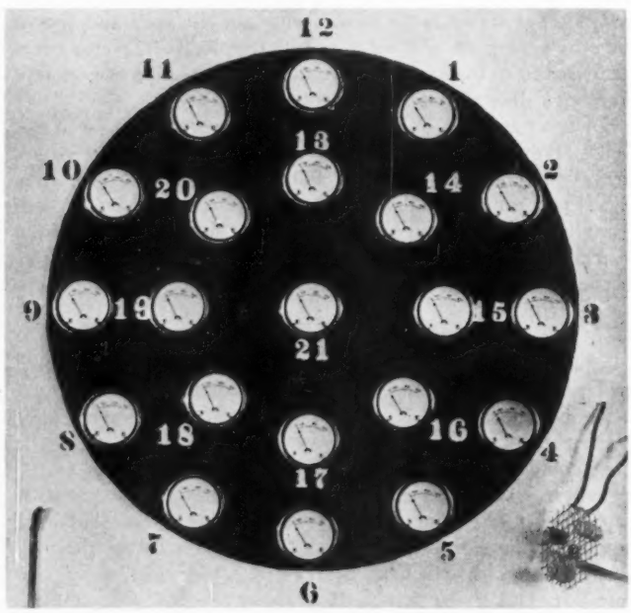


FIG. 4 AMMETERS ARRANGED IN POSITIONS CORRESPONDING TO POSITIONS OF ELECTRODES IN PIPE

(Salt injection tube shown in lower left-hand corner; one pair of electrodes in lower right.)

RESULTS AND CONCLUSIONS

By means of a rubber stamp, diagrams could be made which showed the cross-section of the pipe and the location and relative size of the electrodes. On these diagrams, curves were drawn indicating the area of pipe cross-section affected by the salt solution for the three different velocities. See Figs. 5, 6, and 7. A cross on these diagrams indicates the relative position of the injection tube.

An arbitrary method had to be chosen to show the salt dispersion. Curves were drawn in such a way as to include all of the active instruments, to pass through those moderately affected, and just to touch those affected occasionally. The salt dispersion as indicated by the diagram was checked at several stations by an individual point electrode. The results of the single electrode point traverses showed that the indications by diagram were very conservative. It will be seen from Table 1 that when the tube was injecting at the center the spread as indicated by the diagrams is generally less. This is due to the fact that the symmetrical arrangement of the elec-

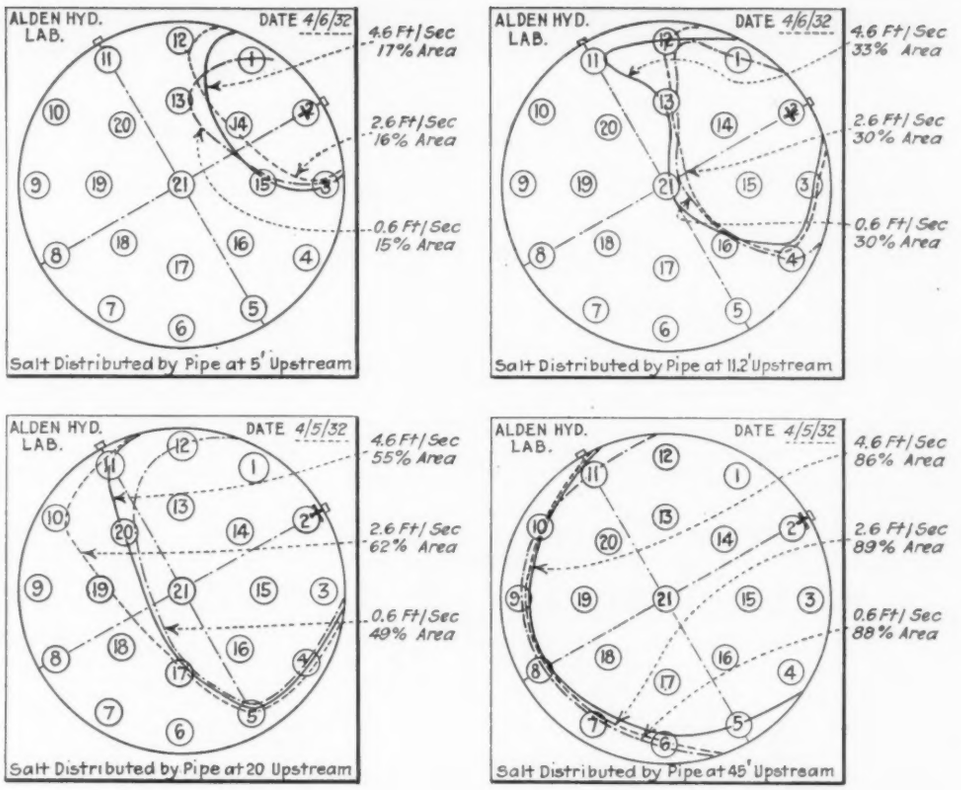

ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 17% Area
2.6 Ft/Sec 16% Area
0.6 Ft/Sec 15% Area
Salt Distributed by Pipe at 5' Upstream
ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 33% Area
2.6 Ft/Sec 30% Area
0.6 Ft/Sec 30% Area
Salt Distributed by Pipe at 11.2' Upstream
ALDEN HYD. LAB.
DATE 4/5/32
4.6 Ft/Sec 55% Area
2.6 Ft/Sec 62% Area
0.6 Ft/Sec 49% Area
Salt Distributed by Pipe at 20 Upstream
ALDEN HYD. LAB.
DATE 4/5/32
4.6 Ft/Sec 86% Area
2.6 Ft/Sec 89% Area
0.6 Ft/Sec 88% Area
Salt Distributed by Pipe at 45' Upstream

FIG. 5 DIAGRAMS SHOWING DISPERSION IN 5 TO 45 FT WITH THREE VELOCITIES OF FLOW
(Salt at same point in each traverse.)

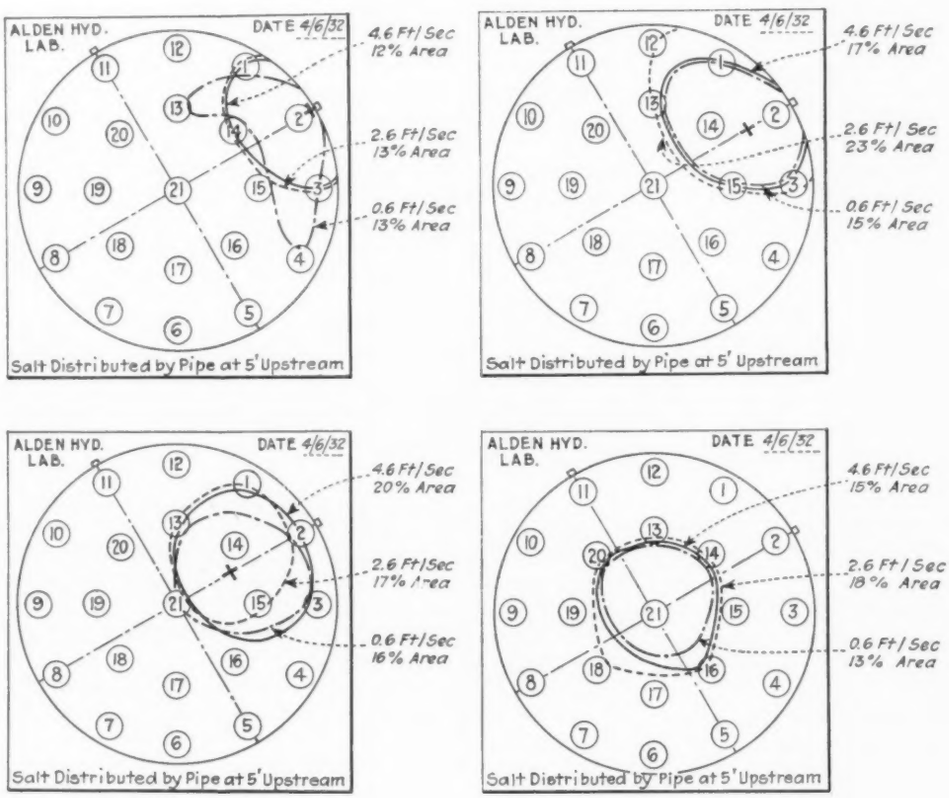

ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 12% Area
2.6 Ft/Sec 13% Area
0.6 Ft/Sec 13% Area
Salt Distributed by Pipe at 5' Upstream
ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 17% Area
2.6 Ft/Sec 23% Area
0.6 Ft/Sec 15% Area
Salt Distributed by Pipe at 5' Upstream
ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 20% Area
2.6 Ft/Sec 17% Area
0.6 Ft/Sec 16% Area
Salt Distributed by Pipe at 5' Upstream
ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 15% Area
2.6 Ft/Sec 18% Area
0.6 Ft/Sec 13% Area
Salt Distributed by Pipe at 5' Upstream

FIG. 6 DIAGRAMS SHOWING DISPERSION IN 5 FT WITH THREE VELOCITIES OF FLOW
(One-half traverse only shown.)

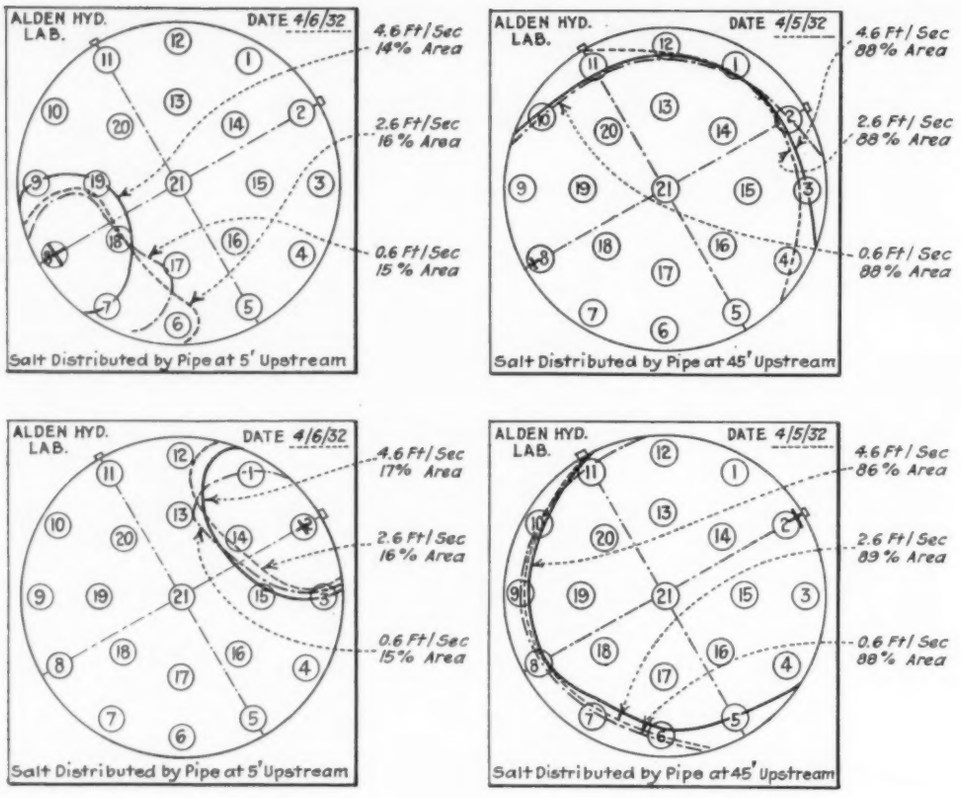

ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 14% Area
2.6 Ft/Sec 16% Area
0.6 Ft/Sec 15% Area
Salt Distributed by Pipe at 5' Upstream
ALDEN HYD. LAB.
DATE 4/5/32
4.6 Ft/Sec 88% Area
2.6 Ft/Sec 88% Area
0.6 Ft/Sec 88% Area
Salt Distributed by Pipe at 45' Upstream
ALDEN HYD. LAB.
DATE 4/6/32
4.6 Ft/Sec 17% Area
2.6 Ft/Sec 16% Area
0.6 Ft/Sec 15% Area
Salt Distributed by Pipe at 5' Upstream
ALDEN HYD. LAB.
DATE 4/5/32
4.6 Ft/Sec 86% Area
2.6 Ft/Sec 89% Area
0.6 Ft/Sec 88% Area
Salt Distributed by Pipe at 45' Upstream

FIG. 7 DIAGRAMS SHOWING THAT DISPERSION IS NOT AFFECTED BY SPECIFIC GRAVITY OF SOLUTION

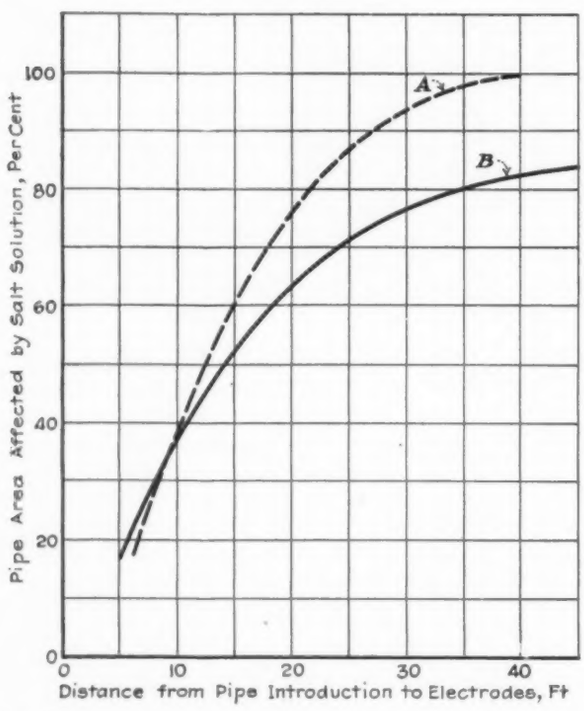


FIG. 8 AVERAGE DISPERSION OF SALT SOLUTION PLOTTED ON DISTANCE TRAVELED PARALLEL TO AXIS OF 40-IN. PENSTOCK; CURVE *A* AREA AS DETERMINED BY POINT-ELECTRODE TRAVERSE; CURVE *B* AREA AS INDICATED BY ARBITRARY PLOTTING OF DIAGRAMS
(Salt introduced through 1/8-in. tube pointed downstream.)

trodes does not clearly define the boundary curve of the salt dispersion. From a study of Table 1 it is apparent that the pipe velocities have little effect upon the salt dispersion. The mean value of dispersion relative to pipe area for a velocity of 4.6 fps is 46.7 per cent, for 2.6 fps, 47.9 per cent, and for 0.6 fps, 41.1 per cent. A study of Fig. 8 shows that the diagram results have much less spread than actually occurs as determined by the point electrode traverse method. With the salt injection tube 45 ft above the electrodes the diagrams indicate 83.6 per cent dispersion, while the actual spread as determined by the point electrode located 40 ft below the injection tube shows 100 per cent dispersion.

A motion picture was made showing the instruments in action with the salt solution being introduced at the various stations.

For work in connection with these experiments, much credit is due L. J. Hooper.

SUMMARY

(1) The dispersion of the salt solution is surprisingly large, especially in the shorter sections.

(2) The amount of dispersion is comparatively constant for all positions in the traverses except those close to the wall.

(3) The amount of dispersion is comparatively constant for the range of velocities used.

(4) No apparent effect on dispersion due to difference in specific gravity of the salt solution and water is shown by the diagrams.

(5) Assumptions of streamline or parallel flow apparently should not be made for ordinary conditions of penstock flow.

CAPITAL-GOODS INDUSTRIES

A Progress Report of a Special Committee of the A.S.M.E.[1]

MECHANICAL ENGINEERS, by inclination, education, and experience, find their occupations in the capital-goods industries. The situation in these industries, therefore—those making machinery and mechanical equipment—vitally affects many of the members of The American Society of Mechanical Engineers. Under conditions of normal business activity these industries account for about 30 billions out of a total of 80 billions of dollars of national business in the United States. They employ normally about eight million workers.

Recognizing these facts, and the further element in the situation that the activity of the capital-goods industries in the United States has dropped to a level of about 30 per cent of normal, the Council of The American Society of Mechanical Engineers authorized the appointment of a special committee to study the prospects for the revival of the industries producing capital goods. This progress report of the Special Committee on Capital-Goods Industries deals with an assay made to determine the attitude of industrialists toward outlays for new machinery and mechanical equipment.

EXTENT AND DISTRIBUTION

To make the assay representative, investigations were carried out in five cities selected to give a geographical spread and for the variety of products turned out: Worcester, Mass.; Philadelphia, Pa.; Atlanta, Ga.; St. Louis, Mo.; and Milwaukee, Wis.

It is a privilege to acknowledge and express gratitude for the assistance of local A.S.M.E. members in each of these cities who secured the information upon which this report is based. A sixth city, Cleveland, Ohio, was also asked to make the same kind of a study. For the reason that a comprehensive survey of a similar nature had been made a few months ago, it was not thought wise to carry through another investigation at this time.

The total number of industrial and business concerns reporting for the five cities is 169. The distribution is as follows: Worcester, 21, Philadelphia, 30, Atlanta, 27, St. Louis, 60, Milwaukee, 31. As to size, those that supplied tabulatable information show that 68 classify as large, 34 as medium, and 37 as small concerns. As regards product, the spread is wide, as is shown in Table 1.

TABLE 1

Textiles	25
Food	23
Chemicals	23
Machinery	22
Paper and printing	18
Iron and steel products	15
Leather and leather products	12
Lumber	9
Stone, glass, clay	5
Non-ferrous metals	5
Tobacco	2
Rubber goods	2
Miscellaneous	8

[1] This committee was appointed in September, 1933. It consists of the following: L. P. Alford, Ralph E. Flanders, W. W. Macon, and L. W. W. Morrow.

THE QUESTIONS AND THE REPLIES

Information as to the present-day attitude toward capital-goods installation and the expenditures therefor was sought for in answers to these questions in addition to those needed to classify the returns:

(1) How much have codes of fair practise increased production costs?
(2) Have prices been raised to meet the increase in production costs?
(3) Have you recently surveyed your production costs?
(4) Have you definite plans for modernization of equipment?
(5) What is your present policy toward capital investment?
(6) Has the NRA helped toward self-government in your industry?
(7) Are you optimistic, pessimistic, or neutral toward the general business outlook?

The findings in general are these:

(1) Production costs have increased, with only a few exceptions.
(2) Prices have not advanced to cover the increased production costs, and profits are down in the majority of the concerns reporting.
(3) About two-thirds of the concerns have no plans for modernization of machinery and mechanical equipment.
(4) About 60 per cent of the concerns report that they would not invest in machinery or mechanical equipment at the present time.
(5) As regards the effect of the NRA and the codes of fair practise, the returns are equally divided for and against.
(6) As regards optimism or pessimism toward the immediate future of business, the majority are optimistic.

THE DETAILED FINDINGS

The detailed findings in tabular form follow:

(1) How much have codes of fair practise increased production costs?

Increase, 146
No change, 5

The rates of increase range from 8 to 100 per cent as shown in Table 2.

TABLE 2

Percentage of increase	Number of companies reporting	Percentage of increase	Number of companies reporting
8	1	25 to 30	1
10	3	25.6	1
10 to 12	1	27	1
10 to 15	1	30 to 40	1
10 to 20	1	33 1/3	2
14	1	35	1
15	4	38	1
15 to 18	1	40	3
20	1	50	1
20 to 25	1	65	1
25	6	100	1

(2) Have prices been raised to meet the increase in production costs?

No	68
Yes	24

The replies to this question from St. Louis were phrased to show the effect of cost increases on profits. The returns are:

Profit down	23
Profit the same	7
Profit up	6
Profit not affected	3
Profit affected	11

(3) Have you recently surveyed your production costs?

Yes	103
No	47

(4) Have you definite plans for modernization of equipment?

No	115
Yes	51

(5) What is your present policy toward capital investment?

Do not expect to make such investment	94
Do expect to make such investment	68

(6) Has the NRA helped toward self-government in your industry?

Yes	78
No	78

(7) Are you optimistic, pessimistic, or neutral toward the general business outlook?

Optimistic	112
Pessimistic	35
Neutral	22

TYPICAL QUOTATIONS FROM THE REPLIES

This report can well close with a few typical quotations concerning the two next to the last questions of the group.

In regard to the present policy toward capital investment, our Cleveland correspondent wrote as follows:

The survey made early this year indicated that capital expenditures in the amount of $3,000,000 were contemplated at that time, but unfortunately the bank debacle occurring a little later in the year put this program entirely out of consideration, and it is now further delayed by the uncertainties that are in the air through the actions of the Administration concerning money.

The expenditure for capital goods cannot be divorced from the lack of confidence that is injected into the minds of men and companies with capital to spend. There will be no difficulty about capital goods expenditures following a return of confidence, which can only be inspired by definite pronouncement by the Administration as to its policy.

Other significant facts are these:

Will buy nothing till volume increases.
Will not increase capacity nor investment under present conditions.
Will spend no money till business improves.

Opposed to comments of this kind is the return from St. Louis to the definite question:

Is fear of inflation or doubt as to present governmental program restraining you from making capital investments?

The returns are:

No	46
Yes	12
Uncertain	2

Typical comments under the question: "Has the NRA helped toward self-government in your industry?" are these:

Not yet. We believe the elimination of child labor and sweatshop relief are good; all else is wrong.

Present activities of NRA will wreck the codes of fair practise; they should be confined to wages and labor conditions.

We feel that the codes have gone too far to be of any practical value.

The code evolved in our industry is a very poor one.

The NRA has brought no benefit. We have a larger payroll, higher taxes, and a price war.

Yes. But we fear bureaucracy.

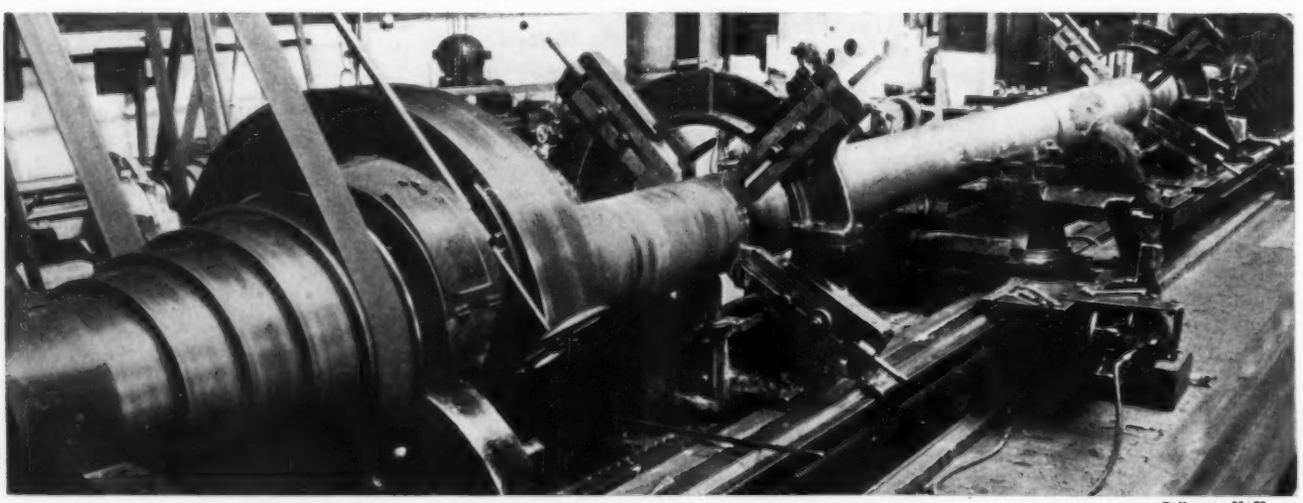
Yes. Bitter competitors are now working together in an association.

Cooperation in industry has improved.

The NRA has brought some benefit to the association with which this industry is connected, but we have grave fears of the labor conditions of code, as well as the existing influence of bureaucracy.

The NRA through the association in this industry has had a very decided advantage and will continue to have, if it works out satisfactorily. It has already succeeded in raising the price level to a more profitable point.

A significant feature of these returns is that essentially the same attitudes and points of view are reported from all five of these industrial cities indicating a unanimity of opinion although the localities are widely separated geographically and a variety of industries were explored.



Galloway, N. Y.

STEAM RESEARCH

I—A Comparison of Derived and Observed Quantities by Means of an Equation of State for Steam Based on the New M.I.T. Volume Data[1]

By F. G. KEYES,[2] L. B. SMITH,[3] AND H. T. GERRY[4]

NEW VOLUME DATA

ONE OF THE two reports[5] presented at last year's meeting reviewed the recent M.I.T. volume data for steam in the superheat region extending from 4 cc per gram to 150 cc per gram over the temperature range 190 to 460 C (374 to 860 F). The graphical extrapolation of the data to the saturated vapor condition was given particular attention and it seemed clear that reliable values of the saturation volumes could be obtained. During the year, additional experience in correlating the data has enhanced our impression that the latter volumes can be secured, but in the present paper a survey will be given of the degree of success attained in the general correlation of the p-v-T data by means of an equation.

The correlation of the older steam volumes, as, for example, the data of Knoblauch, Linde, and Klebe for low pressures, seems to have fostered in many quarters the view that the equation of state for steam in the form $v = \varphi(p, T)$ not only could be relatively simple but that it should be simple. A short experience with the extensive range of steam data now available (to 360 atm) suffices to convince one that the ideal of simplicity is at least not easy to attain. In the course of our efforts we have aimed primarily to represent the data precisely but at the same time to retain a form of equation of state amenable to the manipulation required in steam-table computations. We have been guided from the start in this matter, however, by the indications of statistical mechanics and contemporary knowledge of the molecular field problem which gives information about the equation of state for gases at not too high pressures. In a later paper complete details on these matters will be reported. For the present we merely give the equation for v as a function of p and T and some computations of derived quantities for comparison with the data of our colleagues in steam research.

The formulation of the available new M.I.T. volume data on the vapor phase of steam has been carried forward along two lines. The first was to attempt to represent the volumes as a function of pressure and temperature; the second to represent the pressure as a function of volume and temperature. The latter formulation is by far the easier, but the former is the more readily applicable in computing the quantities of present interest to the mechanical engineer who desires values of the heat function, or enthalpy, $H = U + pv$, volumes at constant pressure, specific heats at constant pressure, etc.

The form of the equation of state for a gas, as already stated, need not be entirely a matter of guess or pure empiricism, for by means of statistical mechanics and the existing body of facts bearing on intramolecular forces, it is possible to deduce the equation of state with precision for low pressures. In this way we find the following equation, where B_0 is a pure temperature function, calculable when the mathematical form for the intramolecular potential is known:

$$p = \frac{RT}{v - B_0} \quad \ldots\ldots [1]$$

(B_0 is a function of T only for low pressures.) This equation is not applicable when the density of the gas becomes large, and, while the extension of the equation to higher pressures by statistical mechanics is possible in theory, the mathematical labor by present methods is almost prohibitive. Our problem may therefore be approached by assuming in accordance with the indications of theory that B is a function of density and temperature of such form that $B \to B_0$ for small densities. It will be assumed accordingly that $B = B_0 + \gamma_1\rho + \gamma_2\rho^2 + \ldots$ in which B_0, γ_1, γ_2, etc., are pure temperature functions. The form of the term B_0 is given by statistical theory, but $\gamma_1 \ldots$ must be determined empirically.

The above equation is, of course, of the form $p = \psi(vT)$, whereas it is convenient to have available a formulation $v = \varphi(p, T)$. To obtain the latter, rewrite Equation [1] thus:

$$v = \frac{RT}{p} + B \quad \ldots\ldots [2]$$

and assume for B the function $B = B_0 + F_1p + \ldots$ where B_0 is the same as above while $F_1 \ldots$ are pure temperature functions. It is to be expected that the complexity of B as a function of pressure and temperature will be greater than for B as a function of volume and temperature, nevertheless, it has been found possible to include volumes to 10 cc per gram in the present pressure-temperature formulation. In this communication only the latter will be discussed, since new computations relative to B as a function of density and temperature have not been entirely completed.

The form of B chosen on the basis of trial was as follows:

$$B = B_0 + F_1p + F_2p^3 + F_3p^{12} \quad \ldots\ldots [3]$$

The value of B_0 in Equation [3], however, was taken, as already stated, from an earlier formulation of B as a function of density of the form $B = B_0 + \gamma_1\rho + \gamma_2\rho^2$ where B_0, γ_1, and γ_2 are temperature functions. In carrying out this formulation each series of pressures and temperatures corresponding to the constant volumes for which measurements existed were utilized to compute the B values. Using the latter corresponding to isotherms, it was then possible to compute values of B_0, γ_1, and γ_2 for each isotherm available. The values of B_0 resulting from this least-square formulation were then employed to

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[4] Massachusetts Institute of Technology.

[5] MECHANICAL ENGINEERING, vol. 55 (1933), p. 113.

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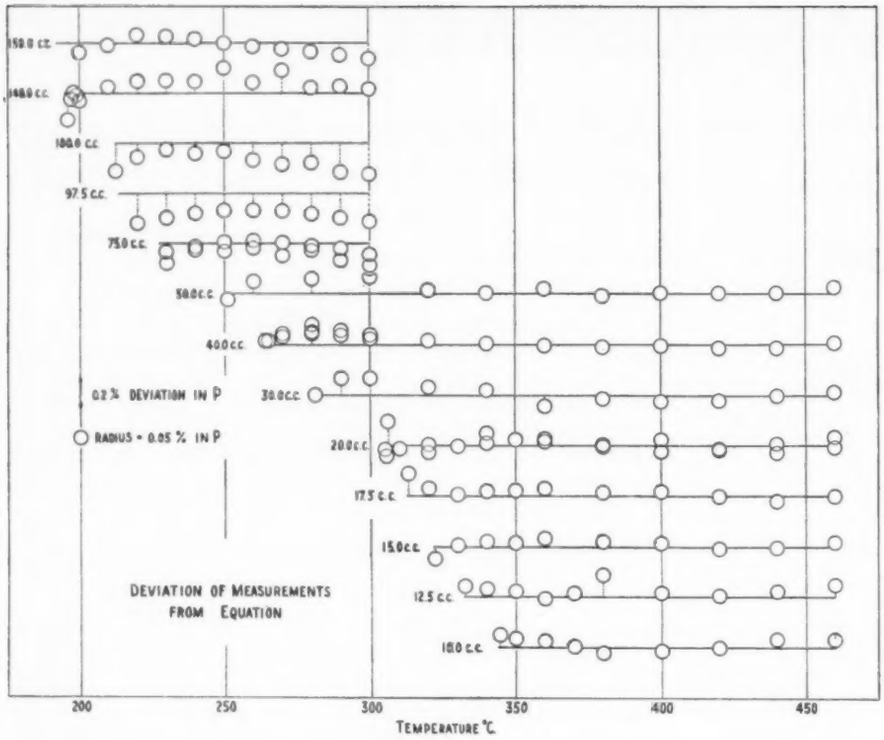


FIG. 1

determine the constants of the equation $B_0 = \beta - \alpha_{1\tau} - \alpha_4\tau^4$ where τ signifies T^{-1}.

The original values of B, employing form [3] were now used to define a new function $(B/B_0 - 1)\cdot T/p = B_{10} = f_1 + F_1/B_0\, p^2\tau^2 + F_2/B_0\, p^{11}\tau^{11}$ and a formulation made using the least-square method. The resulting values of f_1 for each isotherm were then used to determine, by least-square procedure, the constants of the equation $f_1 = \alpha_{01} + \alpha_{11\tau} + \alpha_{41\tau}{}^4$. The former B_{10} values and the computed f_1 quantities were then used to define a second function $B_{20} = (B_{10}/f_1 - 1)\cdot T^2/p^2 = f_2{}^2 + F_3/B_0 f_1\cdot p^9\tau^9$. Repeating the process described for obtaining f_1, the constants of the equation $f_2 = \alpha_{02} + \alpha_{12\tau} + \alpha_{82\tau}{}^8$ were determined by least-square computations. A third function was now defined, $B_{30} = (B_{20}/f_2{}^2 - 1)\cdot T^9/p^9 = f_3$ and the values of f_3 computed using the f_2 equation. Finally, by least-square solution, the constants of f_3 were determined for the form $f_3 = (\alpha_{03} + \alpha_{43\tau}{}^4)^9 - C$, where α_{03}, α_{43}, and C are constants. The final representations for the F's in terms of f_1, f_2, f_3 are as follows:

$$\left.\begin{aligned} F_1 &= B_0 f_{1\tau} \\ F_2 &= F_1 f_2{}^2\tau^2 = B_0 f_1 f_2{}^2\tau^3 \\ F_3 &= F_2 f_3\tau^9 = B_0 f_1 f_2{}^2 f_3\tau^{12} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots [4]$$

The value of B may now be expressed in terms of the f's as follows:

$$B = B_0\{1 + f_1[1 + f_2{}^2(1 + f_3 p^9\tau^9)p^2\tau^2]p\tau\} \ldots\ldots\ldots [3']$$

The numerical equations for the f functions are:

$$\left.\begin{aligned} B_0 &= 0.93386 - 2.00723 \times 10^{+3}\tau - 3.9959 \times 10^{11}\tau^4 \\ f_1 &= 1.8146 \times 10^2\tau + 2.446234 \times 10^{11}\tau^4 - 0.442728 \\ f_2 &= 7.0854 \times 10^2\tau + 1.06983 \times 10^{22}\tau^8 - 8.87252 \\ f_3 &= (6.3 \times 10^{11}\tau^4 - 0.63)^9 - 480 \\ R &= 4.555; \quad T = 273.16 + t\ (\text{deg C}) \end{aligned}\right\} \ldots [5]$$

v is in cc per gram; pressures in international atmospheres.

COMPARISON OF THE COMPUTED PRESSURES WITH THE OBSERVED PRESSURES

The resulting equation of state [2] with the aid of the functions [5] were used to compute pressures for each of the constant-volume series of measurements. In this way a comparison on the basis of pressures is obtained although the volume is the explicit variable in the equation of state. The data have been used to prepare Fig. 1, wherein the deviations between the observed and computed pressures are entered in percentages of the total pressure for each isometric from 10 cc per gram to 150 cc per gram.

The older data of Knoblauch, Linde, and Klebe[6] were reduced to round temperatures and a comparison made with the volumes computed from the equation of state using the Knoblauch, Linde, and Klebe pressures and temperatures. Table 1 gives the results in detail. However, to obtain a quantitative impression of the accord between the equation of state and the observational material the deviations have been sorted into classes and compiled in Table 2. Table 2 makes evident the difficulty of obtaining consistent data at large volumes or low temperatures and pressures. There seems little doubt that the strong adsorptive property of water vapor is one cause of the difficulty.

Nevertheless, in spite of the poorer showing of the agreement in the case of large volumes, it is believed that the pressures as given by the equation of state may be relied upon to one part per thousand and possibly better over the range from 1500 cc to about 10 cc per gram.

THE EQUATION FOR ENTHALPY

The equation for the heat function H, or the enthalpy, is now easily formulated from the differential equation $(\partial H/\partial p)_T = (\partial v\tau/\partial\tau)_p$. We have:

$$H = H_0 + \int_0^p \left(\frac{\partial v\tau}{\partial\tau}\right)_p dp \ldots\ldots\ldots\ldots [6]$$

and by means of the equation of state [2], [5], the second term of the right-hand member of [6] may be formed. We readily find the equations:

$$H = H_0 + \int_0^p \left(\frac{\partial B\tau}{\partial\tau}\right)_p dp \ldots\ldots\ldots\ldots [7]$$

$$H = H_0 + \frac{\partial B_0\tau}{\partial\tau}\, p + \frac{1}{2}\,\frac{\partial F_1\tau}{\partial\tau}\, p^2 + \frac{1}{4}\,\frac{\partial F_2\tau}{\partial\tau}\, p^4 + \frac{1}{13}\,\frac{\partial F_3\tau}{\partial\tau}\, p^{13} \ldots\ldots\ldots [8]$$

In these equations, H_0 is a pure temperature function and by differentiation with respect to temperature leads to C_{P0}, the

[6] Knoblauch, Linde, and Klebe, Mittheilung über Forschungsarbeiten, Heft 21 (1905).

TABLE 1 COMPARISON BETWEEN THE KNOBLAUCH, LINDE, AND KLEBE DATA OF 1905 AND THE M.I.T. PROVISIONAL EQUATION OF STATE BASED ON THE M.I.T. VOLUME DATA FOR STEAM

(p in atmospheres; observed v — calculated v in per cent; average, 0.149 per cent)

110°	p	1.0775	1.1093	1.3280							
	%	.108	.018	-.196							
120°	p	1.1072	1.3637	1.4867	1.5632	1.6804	1.6988	1.9114	1.9248		
	%	.127	-.276	.557	-.171	-.472	-.913	.000	.003		
130°	p	1.1366	1.6064	1.9796	2.1408	2.1724	2.4161				
	%	.127	-.116	.096	-.585	-.023	.090				
140°	p	1.1659	1.6491	2.2315	2.4823	2.8580	2.8856	2.9791	3.4894		
	%	.116	-.086	.009	.121	.030	.080	.215	-.001		
150°	p	1.1950	1.6913	2.2898	2.5474	2.9627	3.5859	3.7594	3.9797	4.0609	4.6787
	%	.099	-.079	.020	.116	.090	.041	.037	-.058	-.122	.182
160°	p	2.6119	3.0388	3.6807	4.8593	5.2759	5.3360	5.7763	6.0559		
	%	.104	.079	.056	-.020	.165	.175	.223	.250		
170°	p	2.6763	4.9887	5.4845	5.9345	6.2238	6.8333	7.2005			
	%	.086	.009	.289	.254	.292	.310	.122			
180°	p	7.3990	8.0343	8.8586	10.0307						
	%	.175	.101	.148	-.015						
190°	p	10.3166	10.8045								
	%	.050	.061								

TABLE 2 DEVIATIONS OF OBSERVED PRESSURES FROM THE PRESSURES COMPUTED FROM EQUATIONS [2] AND [5]

(M.I.T. Data)

10 cc to 150 cc per gram range	
Total pairs of pressure-temperature points	167
Overall average deviation, per cent	0.0588
10 cc to 50 cc per gram range	
106 points: Overall average deviation, per cent	0.0428
73 points less than 0.05 per cent	
25 points between 0.05 and 0.10 per cent	
8 points over 0.10 per cent	
Maximum deviation, per cent	0.166
75 cc to 150 cc per gram range	
61 points: Overall average deviation, per cent	0.0868
39 points less than 0.10 per cent	
19 points between 0.10 and 0.20 per cent	
3 points over 0.2 per cent	
Maximum deviation, per cent	0.219

(Knoblauch, Linde, and Klebe Data)

Total of 38 points at round temperatures:	
Overall average deviation, per cent	0.149
26 points between 0.00 and 0.10 per cent	
12 points between 0.10 and 0.15 per cent	
12 points between 0.15 and 0.30 per cent	
6 points over 0.30 per cent	

heat capacity of water vapor for zero pressure. Differentiation of H for constant pressure gives the equation for C_p.[7]

To evaluate H_0 several experimental quantities are available; the Koch C_p values,[7] the Davis and Kleinschmidt Joule-Thomson effect values, and the Osborne, Stimson, and Fiock saturated vapor, H_s, values. The latter values extend to 270 C and give H_0 values directly. The Koch heat-capacity data lead conveniently to C_{p0} values[7] and the Joule-Thomson data can be used to compute C_{p0} values from the equation:

$$C_{p0} = T\int_0^p \left(\frac{\partial^2 v}{\partial T^2}\right)_p dp - \left(\frac{\partial v\tau}{\partial \tau}\right) p/\mu \quad \ldots\ldots [9]$$

where μ represents the Joule-Thomson number.

The total ensemble of C_{p0} values deduced from the Koch data and the Joule-Thomson effect data of Davis and Kleinschmidt were united with the H_0 values deduced from the saturated vapor H_s values of Osborne, Stimson, and Fiock and employed to deduce the constants of the following equation by least-square procedure:

$$H_0 = 2498.43 + 1.87376\,t + 1.60538 \times 10^{-4}t^2 + 3.72 \times 10^{-10}t^4 \text{ (Int. joules)}^8$$
$$= (596.85 + 0.4476\,t + 3.835 \times 10^{-5}t^2 + 3.835 \times 10^{-5}t^2 + 8.8875 \times 10^{-11}t^4) \text{ (London Conf. calories)}$$

$$C_{p0} = (1.8738 + 3.211 \times 10^{-4}t + 1.488 \times 10^{-9}t^3) \text{ (Int. joules)} \quad \ldots\ldots [10]$$
$$= 0.4476 + 7.670 \times 10^{-5}t + 3.555 \times 10^{-10}t^3 \text{ (London Conf. calories)}$$

In this formulation values of C_{p0} from the data of Koch close to saturation were excluded because of a sharply increasing trend which was more pronounced the higher the pressure. In Fig. 2 a graphical representation is given wherein the full lines are computed from the Equation [8′] using for C_{p0} the Equation [10] and the equation of state [2], [5] for the remaining terms. The data of Koch are represented by the designated points. It is clear from the figure that the experimental data are systematically larger as the saturation C_p border curve is approached.

The representation of the C_{p0} values from the Joule-Thomson numbers, averaged at each temperature, and those from the

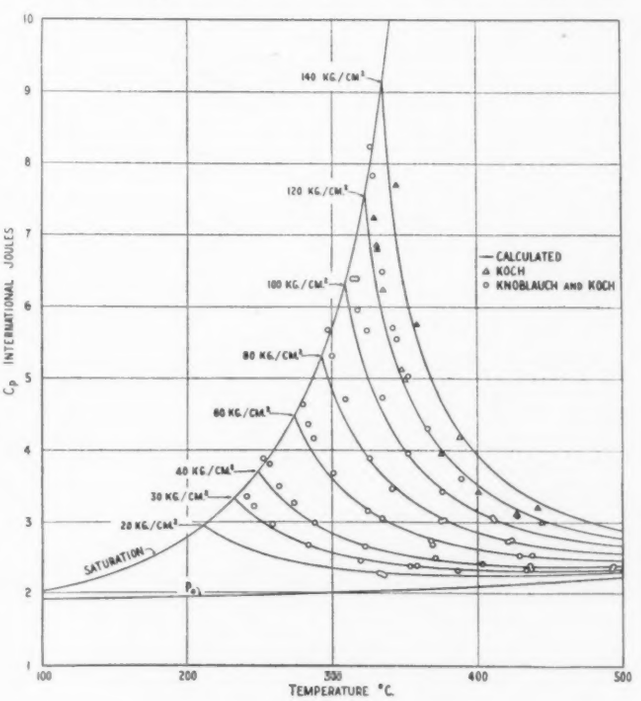


FIG. 2

[7] $C_p = C_{p0} - \tau^2\left[\frac{\partial^2 B_0\tau}{\partial\tau^2}\,p + \ldots.\right]$ .....[8′]

Knoblauch and Koch, *Z.V.D.I.*, vol. 72 (1928), p. 1733.
W. Koch, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 3 (1932), no. 1.

[8] S. Sugawara obtains the following equation in his formulation based on the new steam data reported to February, 1931:
$H_0 = 2497.4 + 1.9088\,(T - 273.2) + 3.0977 \times 10^{-7}\,(T - 273.2)^3$

C_p data of Knoblauch and Koch and Koch have been brought together in a plot as a function of temperature. From Fig. 3 it is evident that the C_{p_0} numbers beginning about 30 deg from saturation from the C_p data increase suddenly. Note should also be made of the relation of the two series of measurements at 120 kg pressure. It is of interest to observe that above 374.11 C, the critical temperature, all data "condense" on the computed full line.

The values of H_s for the saturated vapor may now be computed and compared with the experimental data of Osborne, Stimson, and Fiock. The results are given in Table 3, while

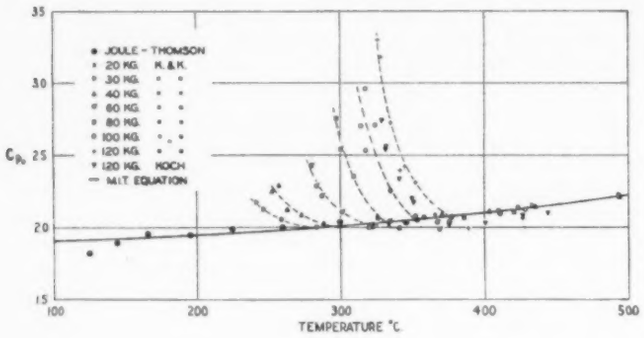


FIG. 3

in Fig. 4 the graphical representation relates the experimental and smoothed Bureau of Standards results to the computed H_s values. The agreement is very satisfactory except below 50 C where no new H_s data are available.

THE DAVIS AND KLEINSCHMIDT JOULE-THOMSON DATA

Turning to the Joule-Thomson data, it is of interest to inspect the accord between the computed effect, using for this purpose the equation:

$$\mu = -\frac{\frac{\partial B_T}{\partial T}}{C_p} \qquad [11]$$

In this equation the numerator is computed entirely from the equation of state [2], [5], while C_p is based on the Equation [10] for C_{p_0} and the equation of state. The results are given in Table 4 and represented graphically in Fig. 5.

THE VALUES OF C_{p_0} OBSERVED AND COMPUTED

Returning to the discrepancy which Figs. 2 and 3 indicate exists between the computed C_p values and the experimental data of Koch near saturation, it is observed that the excellent agreement of the computed quantities with the Harvard Joule-Thomson data and the United States Bureau of Standards data implies that the experimental C_p data near saturation are inconsistent with the whole body of the Bureau of Standards data. This, is however, not necessarily true, since compensating effects enter in the computation of μ and of H_s. Moreover, the fidelity with which the equation of state represents the M.I.T. volume data does not make it inevitable that first and second temperature derivatives may be computed with precision. It must also be emphasized in connection with this point that there is no convincing evidence that the international temperature scale used in the measurements is a sufficiently good approximation to the thermodynamic scale required in the thermodynamic formulas. The situation would be clearer if really reliable experimental values of C_{p_0} were available. Table 5 gives a survey of several reported values of C_{p_0} of which the Reichsanstalt data are experimentally determined.

The agreement is evidently not all that could be desired, but on the other hand it is doubtless as good as may be expected in view of the known difficulties of measuring gaseous heat capacities directly.

Without suggesting that liquid, or rather fog, entrainment is actually the cause of the apparently high values of C_p obtained by Koch as saturation temperatures are approached, it is of interest to note that the largest discrepancy in the measured C_p's would be accounted for by as little as one part of water in the form of fog to 1200 parts by weight of vapor. Further discussion of the smaller computed values of C_p will be presented when the equation of state in the form $p = \psi(vT)$ is in final form.

Before leaving the subject of the C_{p_0} values, we wish to refer to an equation for this quantity given by Wohl and von Elbe.[9]

TABLE 3 OSBORNE, STIMSON, AND FIOCK SATURATED-VAPOR VALUES[1] OF THE ENTHALPY COMPARED WITH SIMILAR COMPUTED VALUES

Temp, deg C	H_s (calc. M.I.T.)	H_s (B. S.)	B.S. — M.I.T.
0	2498.201	2494.02	—4.18
20	2535.305	2534.00	—1.31
40	2572.008	2572.24	0.23
60	2607.945	2608.81	0.86
80	2642.654	2643.48	0.83
100	2675.601	2675.99	0.39
110	2691.233	2691.32	0.09
120	2706.202	2706.01	—0.19
130	2720.431	2719.97	—0.46
140	2733.837	2733.15	—0.69
150	2746.373	2745.51	—0.86
160	2757.846	2756.95	—0.90
170	2768.273	2767.38	—0.89
180	2777.523	2776.82	—0.70
190	2785.495	2785.04	—0.46
200	2792.084	2791.95	—0.13
210	2797.173	2797.35	0.18
220	2800.636	2801.13	0.49
230	2802.334	2803.08	0.75
240	2802.118	2802.99	0.87
250	2799.821	2800.56	0.74
260	2795.256	2795.47	0.21
270	2788.214	2787.83	—0.38

All heats in International Joules per gram.

[1] Computed from smoothing equation given by Osborne, Stimson, and Fiock.

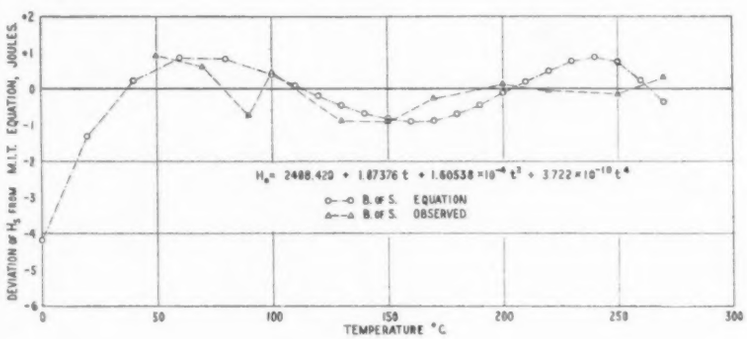


FIG. 4

[9] Wohl and von Elbe, *Zeit. für Phys. Chem.* (B), vol. 5 (1929), p. 241.

The latter is based on an attempt to express the temperature dependence of the heat capacity at zero pressure on the assumption that the vibrational energy of the oxygen atom and each hydrogen atom in the molecule depends entirely on a single frequency. The energy associated with the rotational states of the molecule is assumed to reach the equipartition or classical value $3/2\,R$, where R is the gas constant per mol (1.9857 London Conf. cal). The frequency factor for the oxygen atom is taken as 5370 and double; that for the hydrogen atoms 2280. These are then used additatively on the supposition that the Einstein function is applicable. Wohl and von Elbe give the following equation:

$$C_{P_0} = \frac{R}{18}\left[4 + E(x_1) + 2E(x_2)\right] \quad \ldots\ldots\ldots [12]$$

Let θ represent the frequency factor and θ/T be denoted by x

$$\theta_1 = 2280; \qquad \theta_2 = 5370$$

$\frac{x^2 e^x}{(e^x - 1)^2}$ is the Einstein function, $E(x)$

x_1 is the quantity θ_1/T

x_2 is the quantity θ_2/T

There is much to urge against the conception leading to Equation [12], but for the present it will suffice to mention that agreement has not been reached on the interpretation of the infra-red absorption bands of water vapor, and the energy of rotation associated therewith may also have to be taken into account at the temperatures of interest in steam tables. The vibrational terms $E(x_1)$ and $E(x_2)$ assumed by Wohl and von Elbe have their origin in a simplified conception of the structure of the water molecule which also has not been accepted finally.[10] It must be concluded, therefore, that however well Equation [12] accords with the experimental values of C_{P_0} as at present known, this must not be assumed to justify the ideas used by Wohl and von Elbe as a basis for the C_{P_0} equation.

In Table 6 values of C_{P_0} from the M.I.T. computations and from [12] are given for comparison.

TABLE 4 DAVIS AND KLEINSCHMIDT JOULE-THOMPSON COEFFICIENTS COMPARED WITH COMPUTED VALUES

P, Kg/cm²	°C Kg/cm² D. & K.	Cal. K. & S.
	347 C	
1.60	0.932	0.914
7.38	0.929	0.918
15.00	0.928	0.920
35.00	0.919	0.917
	300 C	
1.70	1.163	1.202
3.16	1.193	1.204
8.44	1.192	1.209
14.00	1.207	1.211
15.00	1.197	1.211
20.25	1.201	1.210
32.70	1.187	1.201
	260 C	
1.60	1.485	1.553
3.16	1.536	1.557
10.55	1.549	1.564
14.77	1.548	1.563
15.11	1.577	1.563
20.00	1.551	1.558
25.30	1.545	1.550
32.40	1.533	1.536
39.60	1.511	1.518

P, Kg/cm²	°C Kg/cm² D. & K.	Cal. K. & S.
	225 C	
1.60	1.882	1.985
3.16	1.995	1.990
7.04	1.978	1.997
10.55	1.948	1.995
14.77	1.987	1.990
20.25	1.953	1.977
20.25	2.001	1.977
	196 C	
1.60	2.368	2.472
3.52	2.409	2.481
7.04	2.557	2.485
7.04	2.474	2.485
7.60	2.522	2.484
10.55	2.570	2.480
10.55	2.490	2.480
	166 C	
1.60	2.973	3.159
1.76	3.092	3.161
2.85	3.209	3.167
5.62	3.264	3.173
	145 C	
1.405	3.730	3.805
2.81	3.998	3.816
	125 C	
1.125	4.801	4.564

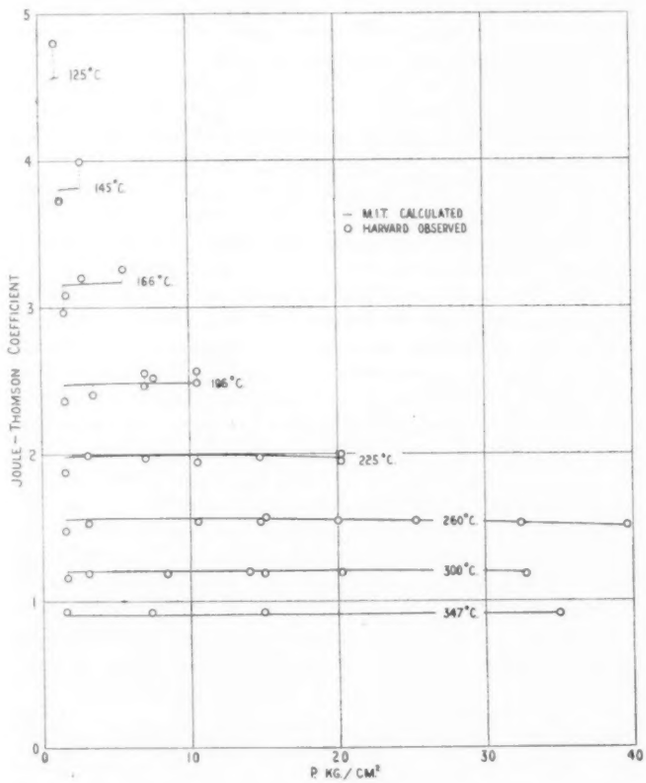


FIG. 5

TABLE 5

t	Reichsanstalt Wärmetabellen 1919 C_p 1 atm, Joules	M.I.T. deduced from C_p, and H, C_p 1 atm	I.C.T. vol. 5, p. 82 Results of Jakob[1]
100	1.934	2.025	2.017
200	1.973	1.986	1.971
300	2.011	2.025	1.996
400	2.050	2.104	2.051

[1] *Z.V.D.I.*, vol. 56 (1912), p. 198.

TABLE 6

Temp, C	C_{p_0} Wohl & von Elbe	C_{p_0} M.I.T. Eq. [10]	C_{p_0} S. Sugawara[1]
100	1.886	1.907	1.915
200	1.937	1.950	1.925
300	1.996	2.010	1.983
400	2.059	2.097	2.042

[1] Sugao Sugawara, Mem. College of Engineering, Kyoto Imp. Univ., vol. 7 (1932), p. 17.

It will be recalled that H. Hausen[11] used the Wohl and von Elbe equation for C_{P_0} as a basis for the deduction of an equation of state for water vapor using the Equation [13]. An exact representation of $C_p - C_{P_0}$ was secured, followed by integration thereby introducing an arbitrary function of pressure. A repetition of the latter process then leads to an equation of state explicit in volume.

[10] See Dr. Max Jakob's remarks, Third Lecture, *Engineering*, vol. 132 (1931), pp. 684–686.

[11] H. Hausen, *Forschung auf dem Gebiete des Ingenieurwesens*, vol. 2 (1931), p. 319.

$$\Delta C_p = C_p - C_{p_0} = -\int T\left(\frac{\partial^2 v}{\partial T^2}\right)_p dp$$

$$= -\int\left\{\frac{\partial}{\partial T}\left[T\frac{\partial v}{\partial T} - v\right]\right\} dp \ldots\ldots [13]$$

$$v = T\int\left[\int\left(\frac{\partial \Delta C_p}{\partial p}\right)_T dT - f_1(p)\right] d\tau - Tf_2(p)$$

$$\tau = T^{-1}$$

Attention has been directed to the difficulty of reconciling the values of C_p found by Koch near vapor saturation with the M.I.T. volume data as represented by Equations [2], [5]. The order of agreement of the C_{p_0} values used by Hausen, Equation [12], and the M.I.T. deduced values (Eq. [10]) taken in connection with the fact that Hausen represents the Koch C_p values satisfactorily makes clear that the latter's equation of state for steam cannot give steam volumes in very exact agreement with the M.I.T. measurements. Direct computations in demonstration of this statement have not been made because of uncertainty about the value of T_0 used by Hausen in forming the thermodynamic temperature. (I.C.T. value is 273.1.) We intend to obtain this information from Doctor Hausen and make the direct calculations.

II—An Equation for the Volume of Liquid Water[12]

BY L. B. SMITH AND F. G. KEYES

AT THE meeting a year ago it was stated that an attempt was being made to formulate the M.I.T. liquid volume data.

An equation of the form:

$$v = \frac{v_s + B(p - p_s) + D(p - p_s)^2 + E(p - p_s)^{1/3}}{1 + C(p - p_s)} \ldots [1]$$

has been found to cover the range from 30 C to 360 C in a satisfactory manner.

The constants v_s, B, D, E, and C are all functions of temperature and have been separately formulated. The saturation volume v_s has been represented by the following equation:

$$v = \frac{v_c + a(t_c - t)^{1/3} + b(t_c - t) + c(t_c - t)^4}{1 + d(t_c - t)^{1/3} + e(t_c - t)} \ldots [2]$$

where v_c = critical volume = 3.197500 cc per gram
t_c = critical temperature = 374.11 C
t = temperature, deg C
$a = -3.151548 \times 10^{-1}$
$b = -1.203374 \times 10^{-3}$
$c = +7.48908 \times 10^{-13}$
$d = +1.342489 \times 10^{-1}$
$e = -3.946263 \times 10^{-3}$

The remaining constants have fortunately proved to be much simpler temperature functions, requiring only two or four arbitrary constants each.

$$\log_{10}(-1/E) = a + b(t_c - t)^{1/3}$$

where $a = +4.127788 \times 10^{-1}$
$b = +3.999207 \times 10^{-1}$

$$\log_{10}(-D) = a + b(t_c - t)$$

where $a = -4.9573810$
$b = -2.9752567 \times 10^{-2}$

$$\log_{10} B = a + b(t_c - t)^{1/3} + c(t_c - t) + d(t_c - t)^{2/3}$$

where $a = -1.2925743$
$b = -9.7238056 \times 10^{-2}$
$c = -1.2938329 \times 10^{-2}$
$d = +5.8890279 \times 10^{-4}$

$$\log_{10} C = a + b(t_c - t)^{2/3} + c(t_c - t) + d(t_c - t)^{2/3}$$

where $a = -1.6141307$
$b = -5.2849209 \times 10^{-2}$
$c = -6.9720421 \times 10^{-3}$
$d = +4.5803994 \times 10^{-4}$

The complete equation represents all the measurements of the latest series from 30 to 360 C inclusive with an average error of one part in 3450, or, excluding the measurements at 350 C, to one in 4710.

Equation [2] represents the saturation volumes to 360 C, exclusive of 350 C, to one part in 7900. The difference at 350 C is about one part in a thousand. The critical volume v_c in Equation [2] was determined in the least-square treatment of the data. The value 3.1975 cc per gram, so obtained, agrees fairly well with values from other sources.

It is interesting to note that the complete equation gives a minimum volume between 0 C and 10 C and a minimum compressibility at about 30 C, in good qualitative agreement with the known behavior of liquid water.

Differentiation of the liquid-volume equation with respect to pressure at constant temperature gives a term $\frac{1}{2}E(p - p_s)^{-1/2}$ which becomes infinite when $p = p_s$. This requires an infinite compressibility at saturation for all temperatures. No significance is attached to this peculiarity of the equation since it is at variance with the known fact that, under proper conditions, the saturation state may be approached and passed with no break in continuity. It is perhaps unfortunate that the equation takes this form as it seems reasonable to suppose that some other form, giving a finite derivative for all points, might have been found to represent the data. Indeed, at low temperatures the isotherms may be represented with a high degree of precision by a simple quadratic equation.

The agreement between experimental measurements of the different series can best be shown by reference to the deviation plots, Fig. 6, where differences between calculated and observed volumes are plotted. With the exception of a few points close to saturation, all values for the stainless and chrome-vanadium series are seen to be consistent to better than a part in 3000. The average consistency appears to be perhaps as great as a part in 7000 or 8000.

Up to 100 C the measurements made in nickel are in excellent agreement with those made in stainless steel, maximum differences being about one in 5000. At 150 C and 250 C, the nickel

[12] Contribution No. 321 from the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, Cambridge, Mass.

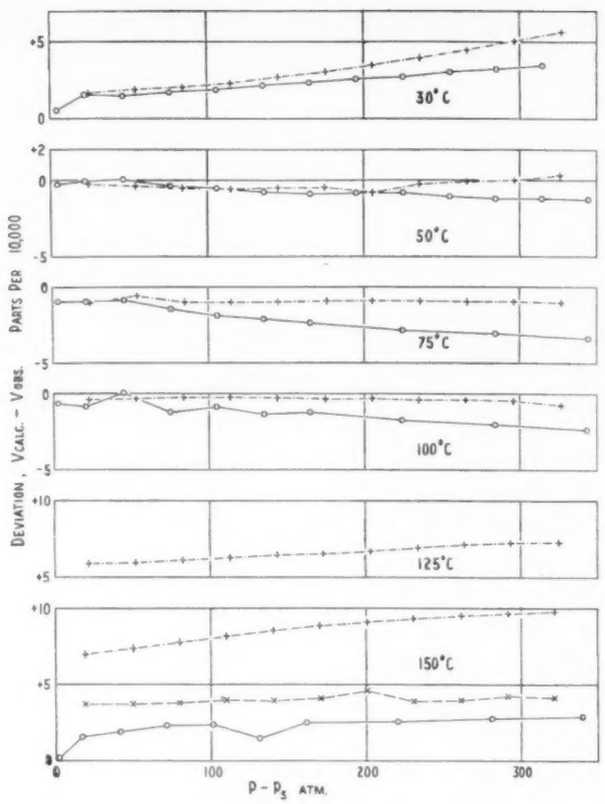


FIG. 6 SECTION A

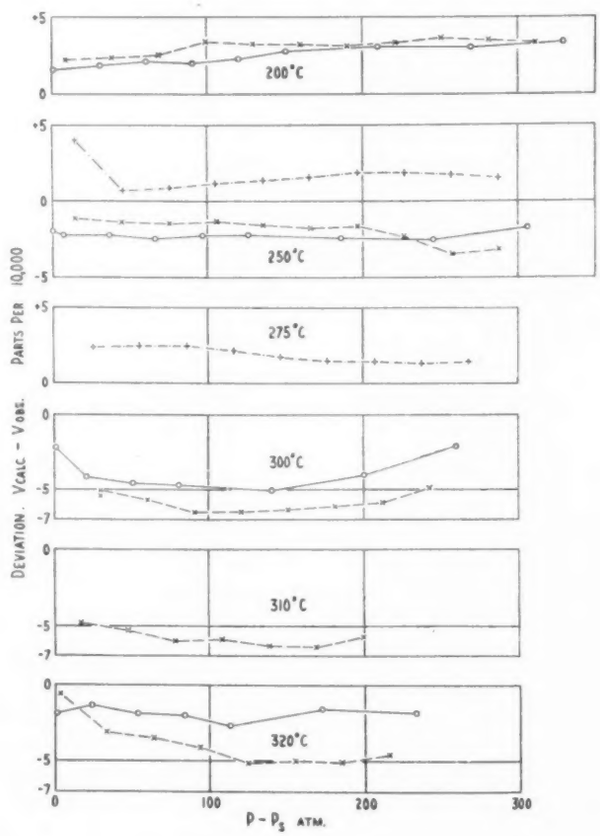


FIG. 6 SECTION B

series exhibit differences from the other measurements of a part in 2000 or 3000 and at 300 C, the highest temperature measured in the nickel run, the differences are about one in 250.

DERIVED THERMAL PROPERTIES OF LIQUID WATER

The measurements of total heat of saturated water, made by Osborne, Stimson, and Fiock[13] at the Bureau of Standards, may serve as the basis for calculating certain other interesting thermal properties.

Thus, the constant-pressure specific heat at saturation may be calculated from the following thermodynamic relationship:

$$C_p = \left(\frac{dH}{dT}\right)_{sat} - \left[v - T\left(\frac{\partial v}{\partial T}\right)_p\right]\left(\frac{dp}{dT}\right)_{sat}$$

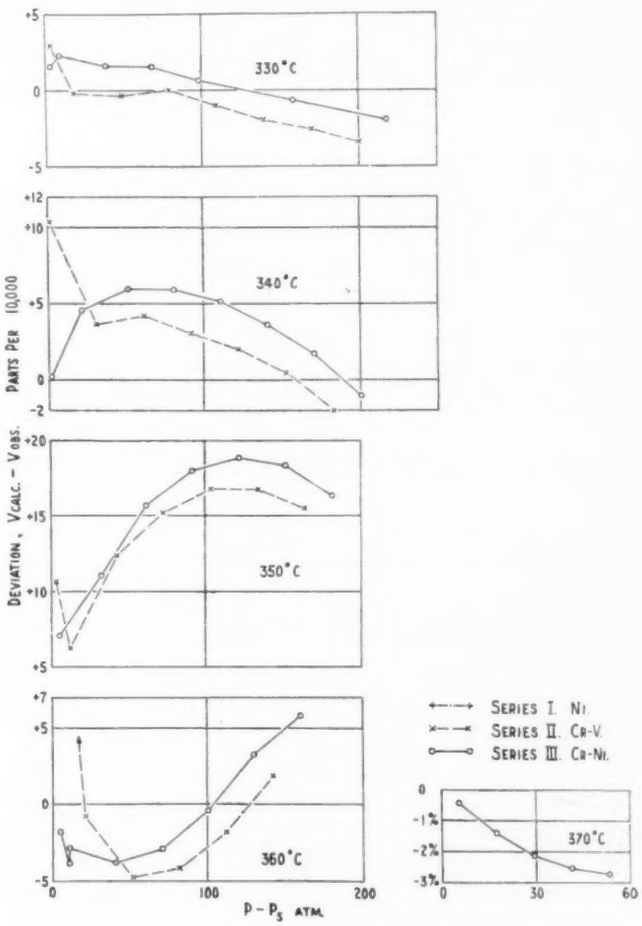


FIG. 6 SECTION C

The derivative $\left(\frac{dH}{dT}\right)_{sat}$ was obtained from the tabulated values of H of Osborne, Stimson, and Fiock, using the method of Rutledge.[14] The derivative $\left(\frac{\partial v}{\partial T}\right)_p$ was similarly calculated from our tables of liquid volumes. The derivative $\left(\frac{dp}{dT}\right)_{sat}$ was calculated by the differentiation of our vapor-pressure equation.

[13] Osborne, Stimson, and Fiock, Trans. A.S.M.E., vol. 52 (1930), paper FSP-52-28.

[14] Rutledge, *Physical Review*, vol. 40 (1932), p. 262.

The constant-volume specific heat, at saturation, is given by the thermodynamic equation:

$$C_v = C_p + \frac{T\left(\frac{\partial v}{\partial T}\right)_p^2}{\left(\frac{\partial v}{\partial p}\right)_T}$$

The derivative $\left(\frac{\partial v}{\partial p}\right)_T$ was obtained by differentiating our liquid-volume equation.

The constant-pressure specific heat for compressed liquid water was calculated for a few points from the specific heat at saturation as follows:

$$C_p = C_{p_s} + T\int_{p_s}^{p}\left(\frac{\partial^2 v}{\partial T^2}\right)_p dp$$

Similarly, the total heat for compressed liquid water has been calculated for a few points. The thermodynamic relationship is

$$H = H_{sat} + \int_{p_s}^{p} v\,dp - T\int_{p_s}^{p}\left(\frac{\partial v}{\partial T}\right)_p dp$$

The values of C_p and H thus computed are given in Table 8.

The calculation of other thermal properties for liquid water may be carried out in an analogous manner from the data now available.

TABLE 7 SKELETON VOLUME TABLE CALCULATED FROM EQUATION

Temp, deg C	Volumes in cc per gram				
	V_s	50 atm	100 atm	200 atm	300 atm
0	1.000229	0.997952	0.995724	0.991412	0.987278
20	1.002045	0.999808	0.997617	0.993367	0.989286
40	1.007910	1.005661	1.003455	0.999169	0.995050
60	1.017024	1.014719	1.012450	1.008045	1.003806
80	1.028925	1.026522	1.024146	1.019530	1.015093
100	1.043378	1.040839	1.038301	1.033377	1.028650
120	1.060319	1.057604	1.054839	1.049490	1.044362
140	1.079819	1.076898	1.073824	1.067893	1.062233
160	1.102086	1.098939	1.095449	1.088737	1.082368
180	1.127474	1.124118	1.120054	1.112292	1.104979
200	1.156516	1.153037	1.148178	1.138983	1.130413
220	1.189999	1.186626	1.180641	1.169453	1.159188
240	1.229080	1.226359	1.218708	1.204672	1.192077
260	1.275510	1.274692	1.264421	1.246130	1.230236
280	1.332077	.....	1.321333	1.296223	1.275402
300	1.403569	.....	1.396485	1.359084	1.330268
320	1.499236	.....	.....	1.442784	1.399151
340	1.640848	.....	.....	1.567110	1.490820
360	1.906617	.....	.....	1.814014	1.623164

TABLE 8

Temp, deg C	C_{psat}	$C_{p100\,atm}$	H_{sat}	$H_{100\,atm}$
	International Joules			
50	4.1765	4.2003	209.11	217.84
100	4.2127	4.2354	418.75	426.28
200	4.4958	4.5424	852.02	855.63

III—Progress of Work at the U. S. Bureau of Standards[15]

By N. S. OSBORNE,[16] H. F. STIMSON,[16] and D. C. GINNINGS[17]

THE extent of progress to date in the calorimetric determination of the heat content, or enthalpy, of saturated liquid and vapor can be seen by reference to Fig. 7. The portion between the freezing point and 800 lb per sq in. was covered in the initial program, completed in 1930. In the supplementary program, to extend the scope of saturation data, a pressure of 2400 lb per sq in., corresponding to a temperature of 350 C, was taken as the objective as recommended by the advisory committee. This objective has now been reached and passed. The experimental results obtained for the liquid thoroughly cover the range up to 3050 lb per sq in. (370 C). For the vapor the results are not so complete, but include determinations at 1750 lb per sq in. (325 C) and at 2400 lb per sq in. (350 C). Further experimental work on this part is planned to include more points and additional observations to verify the present provisional values. The present values are, however, considered sufficiently reliable to indicate where current steam tables may need to be modified.

The fact that the supplementary experimental program is not entirely complete need not cause disappointment. In addition to the extension of the liquid line of enthalpy to nearly fourfold of the previous pressure range, and the vapor line of enthalpy to threefold, the vapor-pressure relation has been satisfactorily verified between atmospheric pressure and the critical region. Regret that the work on the vapor has not been carried to as satisfactory a completion as the rest of the program is offset by the prospect that the work need not be discontinued immediately.

It scarcely needs mention that the work has not been free of difficulties which have interrupted continuous progress of the measurements. The most pernicious of these afflictions were failures in electric insulation, apparently induced by exposure to the higher temperatures. They were easy to detect, but difficult of access and repair. At present, the work is temporarily halted by a leak that developed in the liquid-outflow tube after two years of service.

Aside from these faults of materials, the operation of the

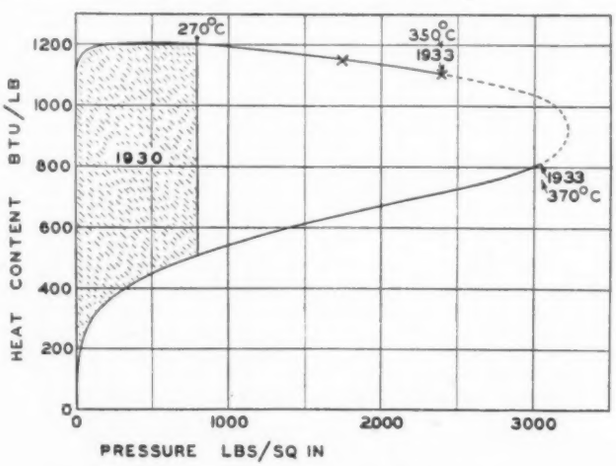


FIG. 7 PROGRESS OF CALORIMETRIC DETERMINATIONS

[15] Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

[16] Physicist, Bureau of Standards, Washington, D. C.

[17] Assistant Physicist, Bureau of Standards.

calorimeter has proved very satisfactory. The excellent performance of the controls and of the measuring elements has made it possible to obtain concordant results, and to make numerous checks to guard against systematic errors. These checks, which include confirmation of earlier results obtained with another calorimeter in the lower range, will be more fully described in the forthcoming comprehensive report. The apparatus used has been described in previous reports.[18]

The measurements in this series of determinations have been made by the general method previously described.[19] In that method three types of experimental process are employed, designated as alpha, beta, and gamma. Combinations of the alpha and beta results yield values of heat content of the saturated liquid; combinations of the beta and gamma results yield values of the heat of vaporization, and thus establish values for heat content of the saturated vapor.

Provisional values of these three properties are given in

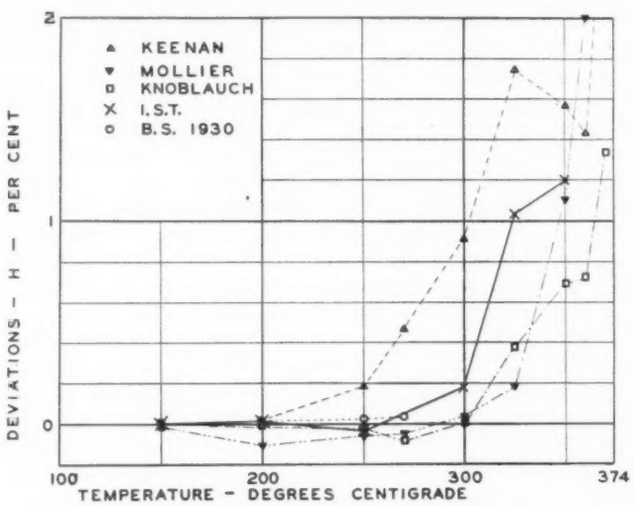


FIG. 8 DEVIATIONS OF HEAT-CONTENT VALUES FOR SATURATED WATER FROM PRESENT PROVISIONAL B.S. VALUES

Table 9. Any further adjustment of the liquid values will be small, as the experimental work for these is now considered adequate. Further adjustment of the vapor values as the result of additional observations may be greater.

TABLE 9 PROVISIONAL VALUES OF HEAT CONTENT

Temp, deg C	Liquid H	Vapor H'	Latent heat L
	International joules per gram		
150	631.7	....	....
200	851.9	....	....
250	1085.3	2799.2	1713.9
270	1184.7	2789.6	1604.8
300	1344.5	....	....
325	1492.9	2682.4	1189.5
350	1671.1	2564.3	893.2
360	1672.0	....	....
370	1892.0	....	....

Deviations of several of the current steam tables from these data are shown in Figs. 8 and 9. These deviation charts show that substantial changes in the values of heat content for both liquid and vapor may be anticipated, and they give an approximate idea of the amounts as indicated by the present results.

[18] MECHANICAL ENGINEERING, vol. 54 (1932), no. 2, p. 118. *Ibid.*, vol. 55 (1933), no. 2, p. 116. Trans. A.S.M.E., 1933, paper RP-55-4, p. 51.

[19] Trans. A.S.M.E., 1930, paper FSP-52-29, p. 221.

Opportunity has been found for a study of available data on saturation pressure of steam, with the object of obtaining a formulation suitable for defining the relation of pressure to temperature in compiling steam tables. The results of this work are presented in a separate report.

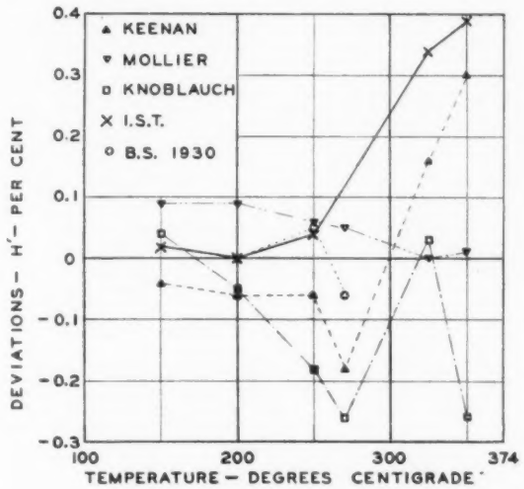


FIG. 9 DEVIATIONS OF HEAT-CONTENT VALUES FOR SATURATED STEAM FROM PRESENT PROVISIONAL B.S. VALUES

As to future experimental work on the calorimetric measurements, diligent effort will be exerted to obtain complete results for early consideration.

Standard Methods for Electrical Measurements

THE long-awaited recommended practise on "Electrical Measurements," developed by the A.S.M.E. Power Test Codes Committee on Instruments and Apparatus, will probably become available in March, 1934. Throughout the progress of the work, the A.S.M.E. Committee had the complete cooperation of the A.I.E.E. Standards Committee, and upon its completion the Institute gave its full approval.

Electrical and mechanical apparatus are often closely associated in the generation and use of power. In 1918, when the Committee on Power Test Codes of The American Society of Mechanical Engineers outlined the scope of its work, it was natural for it to arrange for the development of supplementary material on electrical measurements. Such a section of "Instruments and Apparatus" was, subsequently, developed by Power Test Codes Committee No. 19, C. F. Hirshfeld, chairman.

The first draft of "Electrical Measurements" was completed and distributed for criticism and comment in February, 1927. Extensive revisions were the result, and in December, 1928, the second draft was presented. Further refinements seemed necessary, and therefore a third and final draft was prepared. The members of the committee most closely associated with this development are F. Malcolm Farmer and Everett S. Lee.

For those who may not have seen copies of one or more of the preliminary proofs it should be said that "Electrical Measurements" contains sections on voltage, current, power, energy, resistance, frequency, and power-factor measurements, instrument transformers, load rheostats, and input of motors and output of generators. The last-named section is the one to which the greatest amount of attention was given by the reviewers and the committee feels confident that it now records a definite step in advance. The prepublication price to A.S.M.E. members has been set at $1.

A.E.C. ASSEMBLY MEETS

J. F. Coleman Elected President of The American Engineering Council; F. M. Feiker Succeeds L. W. Wallace as Executive Secretary

THE VITALITY of the American Engineering Council as an aggressive and going concern was convincingly demonstrated at the Annual Meeting of its Assembly, on January 12, 1934, at the Hotel Washington, Washington, D. C. Coincidentally with the meeting came the announcement of the resignation of the executive secretary, L. W. Wallace, who has held this position throughout the thirteen years of the life of the Council. Mr. Wallace leaves the Council to become vice-president in charge of the Washington office of the W. S. Lee Engineering Corporation. F. M. Feiker, member, A.S.M.E., has been elected to succeed Mr. Wallace.

JOHN F. COLEMAN
President, A.E.C., 1934–1936

At the meeting of the Assembly, John F. Coleman, past-president, American Society of Civil Engineers, was elected president of the Council for the usual term of two years. Mr. Coleman succeeds W. S. Lee. Other officers elected were A. J. Hammond, president, Am.Soc.C.E., and Paul Doty, president, A.S.M.E., vice-presidents; C. E. Stevens, treasurer; and C. O. Bickelhaupt, vice-president, to fill the unexpired term of J. F. Coleman.

NEW EXECUTIVE SECRETARY WELL-KNOWN IN WASHINGTON

Members of the A.S.M.E. will remember Mr. Feiker for his service on the Committee on Meetings and Program, of which he was chairman in 1932. A New Englander by birth and a graduate of the Worcester Polytechnic Institute, Mr. Feiker has spent much of his life in editorial and publishing work. He was at one time editor of *System*, leaving it to come to the McGraw-Hill Publishing Co. as editor of *Electrical World*. Later he became a vice-president of the McGraw-Hill Publishing Co. When Mr. Hoover was Secretary of Commerce, Mr. Feiker's services were loaned to that department and he became assistant to the secretary during the reorganization of the department. So valuable were these services and so highly esteemed was Mr. Feiker, that, as President of the United States, Mr. Hoover once more called upon Mr. Feiker, this time to head the Bureau of Foreign and Domestic Commerce of the Department of Commerce. Between these periods of governmental service Mr. Feiker was operating vice-president of the Society for Electrical Development and later managing director of the Associated Business Papers, an association of publishers of business and technical papers.

With the change of national administration, Mr. Feiker returned to semi-private life, devoting his time and efforts to an educational survey of textile engineering education for the Textile Foundation, a connection which he retains, temporarily at least, while serving the American Engineering Council.

Well and favorably known to the many governmental departments at Washington, familiar with publishing and trade-association work, talented as an organizer, possessed of great personal charm, and holding high ideals for the engineering profession and for its relations with the public, Mr. Feiker is peculiarly fitted for the responsibility he has undertaken with the American Engineering Council.

REPORTS ON WORK OF THE COUNCIL DURING 1933

The A.S.M.E. delegation at the meeting of the Assembly consisted of President Paul Doty, Past-President A. A. Potter, Messrs. L. P. Alford and D. Robert Yarnall, and Prof. J. W. Roe, who served as alternate for Ralph E. Flanders.

Following the opening of the meeting of the Assembly, with President W. S. Lee in the chair, it was announced that since, during 1934, the Assembly and the Administrative Board would be identical in membership, they would therefore sit and act jointly.

President Lee summarized some of the important work that the Council had been and was doing and presented some interesting statistics relating to the men who had sat in the Council and their affiliations and attainments. He emphasized the increasing importance of the engineer in public affairs, a fact which added greatly to both the opportunities and the responsibilities of the Council.

In the executive secretary's report, Mr. Wallace spoke feelingly of his thirteen years of service and of what this service had meant to him. The past year, he said, had been a discouraging one because there had never before existed so many opportunities for the Council to be of service, yet facilities for taking advantage of these opportunities had never been so inadequate.

He then reviewed what had been done in cooperation with some of the newer agencies, such as the NRA, the PWA, the TVA, and the CWA. One of the most important services rendered was the preparation of lists of engineers who

could be called upon to serve these and other agencies. In one case, 40 per cent of the appointments to engineering positions had been made from the lists submitted. In another, where a commissioner was to be appointed, the Council had defined the qualifications that the appointee should have and had submitted six nominations. The commissioner appointed was one of the six nominees.

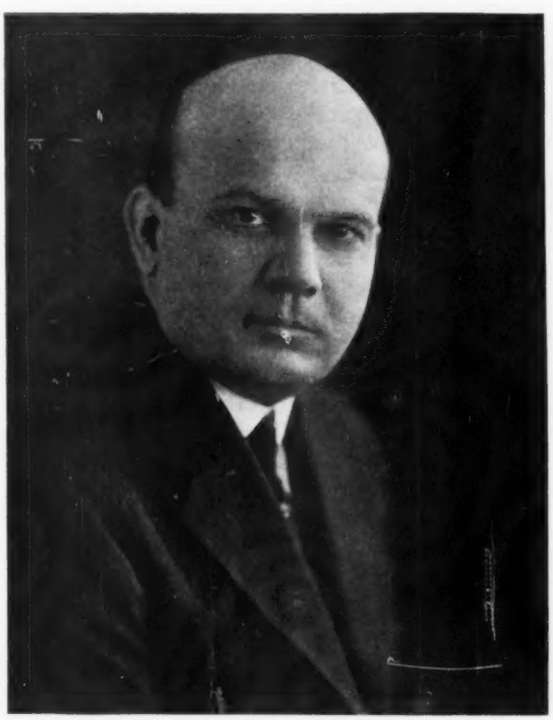
In speaking of his retirement from the secretaryship, Mr. Wallace said that the relationship of the American Engineering Council to the numerous governmental agencies was firmly established and would continue in spite of changes in the national administration and the personnel of the Council. A new administration, he pointed out, brings in new officers and new engineers who need help and advice which the Council is able and willing to give, while the new activities of the Recovery Administration created an enormous demand for engineers and engineering advice.

ACTIONS TAKEN AND SUBJECTS DISCUSSED AT THE ASSEMBLY MEETING

On the motion of Past-President Potter, an expression of gratitude was voted to President Lee, Vice-Presidents Stillwell and Marshall, and Secretary Wallace.

President Doty, A.S.M.E., reported the resolution which the A.S.M.E. Council had passed enthusiastically endorsing the recommendation of its delegates' conference in favor of continuing to support the idea of the American Engineering Council.

The budget of the American Engineering Council, which, because of the financial conditions of the engineering societies, had been reduced to a minimum, was adopted, with the understanding that the executive committee was empowered to adjust it as conditions demanded and permitted. The total amount of this budget is less than one-third that of the budget of 1929.



L. W. WALLACE
Who retires as Executive Secretary, A.E.C.

F. M. FEIKER
Elected Executive Secretary, A.E.C.

The Assembly next considered the statements contained in the executive secretary's report relating to employment conditions for engineers imposed by the Federal Government, particularly in the PWA and the CWA Complaints received by Council were summarized under five headings: (1) the small wage offered engineers by the CWA, in some cases less than that paid to the men whose work they planned and supervised; (2) the unsatisfactory manner in which engineers have to enlist for work; in which is involved, in some cases, (3) the requirement of political endorsement; (4) the taking out of the hands of architects, engineers, and contractors the supervision of the rehabilitation of certain buildings and structures; and (5) the payment of wages in excess of the prevailing rates that encouraged men to leave regular employment in order to obtain work under the relief administration. Following a full debate, in which it developed that these conditions were not uniform throughout the country, a resolution was passed deploring these conditions where they did exist.

On the matter of a resolution of the American Institute of Consulting Engineers asking for certain changes in the Federal Securities Act of 1933, the sympathetic interest of the Council was expressed, and the executive secretary was asked to be of assistance.

TESTIMONIAL TO MR. WALLACE

At the close of the meeting, L. P. Alford presented to Mr. Wallace a group of letters from prominent engineers as a testimonial of their appreciation of his services as executive secretary of the Council. To Mr. Alford's eloquent and appropriate speech, Mr. Wallace replied with deep and genuine feeling, pledging himself to further services in the future.

Mr. John F. Coleman was then inducted into the presidency of the Council, and spoke briefly, assuring the Council of his whole-hearted support of its services.

MECHANICAL ENGINEERING

Vol. 56 FFBRUARY, 1934 No. 2

GEORGE A. STETSON, *Editor*

Professional Engineers' Code

IT HAD been hoped that a statement covering the code for professional engineers, which has been under preparation and revision since last summer and frequently mentioned in these pages, could be published in this issue. In fact, Mr. Henry C. Meyer, Jr., representative of the A.S.M.E. Council in matters relating to the code, had prepared such a statement, and arrangements had been made to publish, in this issue, what had been hoped would be the code in the form in which it would be approved. Developments have determined otherwise; and it can only be reported at the present time that very considerable revisions to the code as published in *Civil Engineering* last fall have completely invalidated that document. As MECHANICAL ENGINEERING goes to press the code is still undergoing discussion and faces uncertain and important changes.

Restrictions on New Machinery

A SURVEY of the industrial codes approved by the President under the NRA reveals the fact that a surprising number of them contain some restriction on the purchase of new machinery. This will do the machinery industries no good, but will retard their recovery and the recovery of business in general, so much of it being related to the capital-goods industries. It would be instructive to know why these restrictions were written into the codes, who sponsored them, and what their object is.

Many codes are still being written or await approval. It is to be hoped that in them attention will be given to the implications to industry and to the effects upon recovery of clauses restricting the purchase of new machinery. Without advocating a policy of scrapping for the sake of purchasing new machinery, or of adding uselessly to capacity, it would be wise to urge the setting up of equipment policies within industries that would bring to the purchase, and scrapping, of machinery an orderliness that would benefit not only the purchaser, but, equally as important, the manufacturer of the equipment. An unhealthy state of affairs has long prevailed in which equipment manufacturers have been forced to extraordinary extremes of activity and idleness, with all their concomitants, and these have had an unbalancing effect on the stability of business.

During the depression, many machinery manufacturers have been improving and modernizing their products. Technological obsolescence is accelerated rather than retarded by dull times. If these manufacturers are to suffer for their forehandedness in being prepared to offer new and improved machinery with which to solve some of the cost problems of the NRA because of restrictions written into NRA codes, they become victims of a short-sighted and uneconomic policy. There is yet time to see that these restrictions do not grow in number, and that those already imposed are relieved where relief is indicated.

Lessons of Technological Change

ONE of the oldest actions that men have taken collectively in the face of disaster, real or imagined, rooted so far in the past that it must antedate all forms, of history, is that of blaming and punishing individuals or groups of individuals for what has happened. Sometimes it is a scapegoat, sacrificed in appeasement, sometimes there is a fairly definite connection between the disaster and the object of public wrath. When things turn out badly we are like Job's brethren, confounded, because we had hoped; and the easy and natural thing to do is to purge ourselves of evil. Iphigenia is sacrificed in Aulis and the Greeks sail for Troy; the doors of Atlanta close on some scapegoat of finance and men's demands for justice are appeased.

More intelligent ways of dealing with disaster and abuse are gradually developing. As long as men sailed in frail boats over stormy seas, the sacrifice of a King's daughter to an unfriendly god could no more guarantee safe passage or calm weather than does the punishment of business men mend the defects in the practises of business, which permit abuses. What the Greeks needed was a knowledge of meteorology, shipbuilding, and seamanship. What the modern world still needs is greater knowledge of reasons for abuses and the causes of disasters and how to avoid them.

Defects and abuses in the industrial world need intelligent study so that they may be corrected and avoided, and to prevent drastic unintelligent actions that operate on the scapegoat principle. This month such a study is presented by Elliott Dunlap Smith. It deals with the stretchout in the textile industry. A reading of Professor Smith's report convinces one that the troubles that arise out of the stretchout are not necessarily inherent in it as a technological development, but are the result of unintelligent management. For he shows.that where the stretchout was introduced with a proper technique and following an adequate study of the collateral problems, the results were satisfactory. But where these factors were not considered, trouble ensued, and the stretchout bore the blame of being the cause of the trouble when the real cause was poor management.

Professor Smith's report confirms a belief that engineers have long held that the trouble lies not with machines and technological developments but with men and their methods. From the days of Prometheus men have been confused in these matters, debating whether

the good or evil flowing from the use of fire and similar advances in civilization predominates. If engineers have an obligation to society with respect to the technological changes they introduce, it lies in bending every effort to make sure that intelligent use is made of them. This means good management. It will probably be found when other technological changes are studied that their harmful social and economic effects are the result of poor management and are not necessarily inherent in the changes themselves.

American Engineering Council

THE RESIGNATION of L. W. Wallace as executive secretary of the American Engineering Council provides an appropriate occasion on which to direct attention to the work of this organization and to bespeak for it the sympathetic support of engineers. Certain imperishable monuments of the service that engineers have rendered this country and its industries through the Council exist in the reports prepared by it or under its direction and published in book form: "The Twelve-Hour Shift in Industry," "Waste in Industry," "Safety and Production," "Industrial Coal," and "Civil Aviation." They represent projects in which engineers, through the American Engineering Council, were able to cooperate with the Government in studies of problems of broad economic and social significance. It is a matter of pride and satisfaction to members of the engineering societies of which the American Engineering Council is composed that their individual and collective support made it possible to demonstrate in such a tangible, permanent, and effective manner the high quality of the services that professional groups can render in the common good.

But important and commendable as these studies and reports have proved to be, it must not be forgotten that the American Engineering Council, during the thirteen years of its existence, has rendered daily and continual service in other ways that have received lesser public notice. There have been, for example, services to government bureaus and departments where the influence of expert and informed opinion has been an important factor in matters affecting their welfare and development. When occasions arise in which the services of individual engineers are needed by governmental and public bodies, the American Engineering Council has been able to supply lists of names from which officials can make appointments. This is a public relationship of the most practical sort, for it places at the service of these officials an enormous wealth of unprejudiced information about the professional qualifications of practically every member of the entire engineering profession.

By keeping a watchful eye upon legislation before the Congress, the Council is able to perform the double function of analyzing the content and implications of those bills as they relate to the welfare of the engineering profession, and also to offer such advice, based on professional knowledge, to the framers, proponents, and opponents of a particular bill, as will insure the wisest and most intelligent legislation from the point of view of safeguarding the public interest.

The success and high quality of such work as the American Engineering Council is constituted to perform in its triple rôle of serving the engineering profession, the Government and its many official agencies, and the public, depends largely upon two factors; the character and ability of the executive secretary of the Council who is its personal representative in Washington, and the degree of support which he receives from the sixty thousand engineers who make up the societies represented in the Council. The Council has been particularly fortunate in the first of these factors in having had for the thirteen years of its existence the services of L. W. Wallace as executive secretary. His record speaks for itself. Through his efforts the governmental agencies for whose benefits the Council has been instituted to serve have come to look upon the Council as a source of valuable advice and assistance. Mr. Feiker, who succeeds Mr. Wallace, inherits an able and devoted organization, built up by Mr. Wallace, and the consciousness that exists in the minds of governmental agencies in Washington of the high and useful character of the services the Council can render, and adds to this inheritance his native gift of charm and ability and a long experience and acquaintanceship with official Washington. The first factor in the success of the Council is thus assured.

The second factor, that of support by the engineering profession, must also be assured. As Mr. Yarnall pointed out last December in his report on the American Engineering Council to the A.S.M.E., and as Mr. Wallace emphasized in his report to the Assembly, briefly summarized on another page of this issue, there has never existed, since the formation of the American Engineering Council, such a desperate need for its services as now exists in this emergency fight with the degenerating influences of a prolonged economic depression. In the face of the great national emergency of the World War, an enthusiastic zeal to work in a common purpose toward a common and well-defined goal motivated the engineering societies to spend time, money, and services in a patriotic effort to make intelligent use of the engineering brains and ability of the country. The American Engineering Council was not then formed. Today, with another great national emergency demanding the coordinated efforts of all classes of society to combat it, there exists in the American Engineering Council an agency, proved in ability and resourcefulness, enjoying the confidence and respect of the agencies it was set up to serve, and supervised by an executive secretary who is in close contact with the profession and with the needs and problems of the government.

It is a source of pride to all engineers, individually and collectively, to review the attainments of their agency, the American Engineering Council. It is a professional obligation and a patriotic duty for them to support its work and the few unselfish individuals upon whom the burden of that work falls, and the success of it depends.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Strandgren Cyclogiro

IN MECHANICAL ENGINEERING, Vol. 55, No. 11, November, 1933, p. 694, there appeared a brief abstract of the theory of the Strandgren machine, published in *L'Aerophile* for July, 1933. This article has now been published in complete translation as Technical Memorandum No. 727 of the National Advisory Committee for Aeronautics, November, 1933.

The Rohrbach Rotating Wing Airplane

THIS is the first publication of detailed information on this plane which is attracting considerable attention in scientific and aeronautical circles. It is stated that for reasons of patent law, it is deemed inadvisable to reproduce general arrangement drawings, stability of performance calculations, and details of the drive which has been designed for rotating the wings. The machine apparently has not yet been built.

In this plane the usual fixed-wing system has been replaced by a rotating system consisting of three or more narrow chord wings of normal thick airfoil sections braced by means of struts and tie rods to a revolving cantilever shaft. This shaft is continuous across the span and rotates in fully floating bearings carried in a fixed central casing built rigidly into the fuselage structure. The whole wing system is rotated through worm or spiral bevel gears from an engine or engines carried in or at the nose of the fuselage, or in separate nacelles over the fuselage. A free-wheel device or one-way clutch allows full autorotation of the wings in the event of engine failure or when the engines are being throttled below a predetermined speed. Lift is generated by suitably feathering or oscillating the wings throughout the cycle of revolution. This is accomplished by a control gear operating the wings through push-and-pull rods which positively and progressively change the angles of the wings (measured against the respective tangents of the cycle of revolution) to suit the practical operating conditions. The wings rotate in a forward direction at the top of the circle and at sufficiently high speed to develop useful lift around the lower part of the circle, and this useful lift is developed at practically every position around the circle of revolution.

Rolling moments are generated by means of a differential oscillation of the two wing sets, this giving increased lift on one side and reduced lift on the other. Yawing moments are similarly produced by following the forward inclination of lift on the two wing sets, the yawing control being actuated by foot pedals. This is designed to give full control when hovering, since with no air to flow over the tail surface the usual rudder control would be inoperative.

In attempting to explain the Rohrbach airplane design, the author refers to published data concerning the Strandgren-Platt cyclogiro machines and tests carried out by the National Advisory Committee for Aeronautics in the United States. The German tests were carried out by the German Experimental Bureau for Aircraft, and it is claimed that the effective angles of incidence at all speeds are positive and progressively controlled throughout the cycle of revolution to produce forces of the required direction and amount with the least expenditure of power. Just how this is done is not revealed for patent reasons. Some data, however, are given.

It is not clear whether these data refer to a purely paper design or a machine that has been actually built or is under construction. The present tense is used, however, in the description of the machine. Thus, it is stated that the plane is fitted with one engine of 240 hp, and that the wings, which have a mean ratio of 14:1, project $14^1/_2$ ft on each side of the fuselage. Three wings are fitted to each rotor and revolve with a maximum speed of 420 rpm, corresponding to a peripheral speed of 260 ft per sec. The minimum rotational speed to produce sufficient lift forces is 270 rpm.

A diagram in the original article (p. 1123) shows the air forces acting on the revolving wings in various positions and under several operating conditions. Flying performance with 2100 lb all-up weight is given as 124 mph at full throttle; minimum speed at sea level, 0; backward speed at sea level, 19 mph. The matter of oscillation control of Rohrbach rotating wings is discussed in general terms only. (W. S. Shackleton, *Flight*, vol. 25, no. 44 and 45 (1927 and 1928), Nov. 2 and 9, 1933, pp. 1087–1090 and 1122–1124, illustrated, *d*)

The Latest Autogiro

THIS machine was demonstrated on Nov. 8, 1933, by de la Cierva at Hanworth (England) and is to be known as C30. The essential difference between this machine and the one demonstrated on April 27 lies in the installation of a 140-hp Armstrong-Siddeley seven-cylinder Genet-Major engine instead of a similar five-cylinder engine with a capacity of 100 hp. It has no fixed wings, no moving ailerons, elevators, or rudder. All that remains of the conventional airplane is the fuselage, landing gear, and tail unit, the latter consisting of a tail plane with upturned ends and an elongated fin. The three folding blades of the rotor are about 8 in. longer than those of the fixed-wing type. The machine is controlled by tilting the entire rotor backward and forward or sideways. The rotor is set spinning by the engine through a clutch and inclined shaft. A new arrangement of struts is used in the C30 to support the rotor mechanism.

In the tests it would appear that the speed of about 120 mph was developed. The machine can be brought down steeply and slowly, but when gliding in with the engine throttled down the forward speed seems to be about 30 mph.

The author of the original article comments particularly on what he calls the medley of mechanism in the cockpit of the present C30 autogiro.

There is the control lever hanging down from the rotor and there is the rudder bar for steering the tail wheel. There is a catch to hold the control lever forward when the rotor is being run up. On the port side are two levers. One applies the wheel brakes, the other works the rotor clutch and the rotor brake.

To let the clutch in, the latter lever is pulled inward toward the pilot and then pulled back. To brake the rotor, after landing, the lever is pushed outward toward the fuselage and

then pulled back. Complication at take-off is somewhat reduced by a quick release on the dashboard which releases the control lever, the clutch, and the wheel brakes simultaneously. It also prevents taking off with the clutch engaged or the control lever locked.

On the starboard side of the cockpit are a wheel to adjust the lateral trim of the machine and a kind of "cheese-cutter" for the longitudinal balance.

In its present state the C30 weighs 1200 lb empty, has a disposable load of 500 lb, and an "all up" weight of 1700 lb. The duration with two up is three hours. A luggage locker 18 in. × 8 in. × 2 ft 6 in. is built in beneath the back cockpit. (*The Aeroplane*, vol. 45, no. 20, Nov. 15, 1933, pp. 858–860, 1 fig., *d*)

ENGINEERING MATERIALS (See also Machine Parts: Piston Rings and Their Relation to Liner Wear; Railroad Engineering: Statistics on Broken Rails)

Extruded Condenser Tubes

THIS is the most recent development in condenser-tube manufacture of the American Brass Co. These tubes are produced by extruding cast billets which previously have been machined to remove surface irregularities. This is claimed to assure clean surfaces inside and out, free from foreign matter and defects. The mechanics of operation are shown in the original article. After extrusion, the tube is cold swage-rolled on a mandrel by an operation which is a combination of forging and rolling. The tube is then finished by annealing and cold drawing and given a final low-temperature electrical anneal to insure a fine and uniform grain structure. These tubes are made in both standard and special alloys which include copper-nickel with 70 per cent copper and 30 per cent nickel, and Ambrac, 70 per cent copper, 20 per cent nickel, and 5 per cent zinc. It is stated that the modulus of elasticity of the 70 copper-30 nickel alloy is from 19 to 20 million. (*Marine Engineering and Shipping Age*, vol. 38, no. 11, November, 1933, pp. 420–421, 6 figs., *d*)

FOUNDRY

Pressure Die Casting of Brass

THIS process of pressure die casting was devised by Joseph Polak in Prague, Czechoslovakia, some four years ago. Five machines are said to be in operation in the United States. The Polak machine operates with hydraulic pressures of between 3000 and 6000 lb per sq in. and it was this feature that made the process practical, because it made possible for the first time the use of a lower casting temperature. The brass is forced into die cavities in a semi-molten or plastic condition rather than in the customary molten state. The lower working temperature makes the process economical because of the greater life obtained from the expensive dies. The details of the process are given in the original article together with microphotographs of pressure castings, forgings, and sand castings, as well as tables of physical properties of brass pressure-cast test bars. These give values of tensile strength in pounds per square inch from 56,700 to 60,000; elastic limit, from 35,750 to 38,000; reduction of area from 4.4 to 10.3 per cent; and elongation in 2 in. from 4.7 to 6.6 per cent. The greatest reduction of area is encountered in a bar comparatively weak in tensile strength. (Wm. W. Šeig, Metallurgist, Titan Metal Mfg. Co., in *The Iron Age*, vol. 132, no. 22, Nov. 30, 1933, pp. 16–19, illustrated, *d*)

FUELS AND FIRING

Coal and Oil

THE author discusses the relative position of the two fuels with particular reference to Great Britain. He mentions the case of Estonia, where there are no coal or oil deposits, but where there are rich deposits of oil shale. A few years ago it was a common sight to see railway locomotives with tenders stacked with piles of buff-colored rock instead of coal. This rock contained more than 50 per cent of incombustible matter and could not be burned with anything like a high degree of efficiency in the boilers. It was used, however, because it was a native product. A shale distillation process has since been adopted and the locomotives are now oil fired. In Great Britain strong complaints against the tax of £1 per ton on oil have been heard from the glass industry. (John Roberts in *Colliery Engineer*, vol. 10, no. 117, November, 1933, pp. 367–368, *c*)

Evaluation of Fuels for Boilers and Gas-Producer Operation

THE article, though of very great interest, is not suitable for abstracting. There is a definite functional connection which can be expressed in mathematical language between the variation in costs of operation of any plant engaged in the production of energy and the technical characteristics of the plant, such as degree of loading and duration of operation. This makes it possible to evaluate by expressing in the form of equations new fuels as compared with fuels previously used, providing certain technical factors about these fuels are known.

To accomplish this the author divides all monthly or yearly costs with any kind of fuel into several groups: namely, costs proportional to the cost of coal K_b, costs proportional to duration of operation K_t, and costs proportional to calendar time (fixed charges) K_k. If it be assumed that the costs of operation with a new fuel are exactly the same as those with an old fuel, then the following equation holds good. $K_b + K_t + K_k = K'_b + K'_t + K'_k$. If five of the members of this equation are known, the sixth can be calculated, and this will give the highest price at which the new fuel will be equal to the one previously used. In the original article the equations given are illustrated by practical examples. (Friedrich Weseman, in *Archiv für die Eisenhüttenwesen*, vol. 7, no. 5, November, 1933, pp. 329–332, *pm*)

Liquid Fuels From Coal for Navy Purposes

THIS paper deals with experiments and tests carried out in the British naval service with liquid fuels produced from coal. The author gives a brief history of the endeavors of the British Admiralty to use creosote as fuel to relieve the dependence of the Navy on imported liquid fuels.

As a result of preliminary tests, the Admiralty prepared a tentative specimen and forwarded it to all known concerns producing oil from coal by low-temperature carbonization. Fourteen of the twenty-five concerns to whom this specification was sent forwarded samples for preliminary tests and six of the firms received sample orders for 20-ton lots for tests. These fuels were submitted to exhaustive mixing trials in combination with petroleum oil fuels in ratios of 2 to 1, 1 to 1, and 1 to 2, and also with the coal oils themselves. These tests

showed that the mixtures remained quite stable and no objectionable deposits were found to separate out, provided the pitch content in the coal oil was kept under about 2 per cent.

In 1932, after the preliminary trials referred to, the Admiralty purchased 350 tons of a low-temperature-carbonization fuel oil from which the tar acids had been extracted. According to information received from the fuel research station, the tar acids in a fuel reduce its heat value by an average amount of about 35 Btu per lb per 1 per cent of tar acids. The oil was delivered to the destroyer *Westminster* and proved to be satisfactory in service. In the present year the Admiralty arranged to purchase 3000 tons, part to be sensibly free from tar acids and a part containing tar acids, the latter desirable because the demand for tar acids for other requirements is limited. Detail results of the tests are not given. (Paper by Engr.-Capt. S. H. Dunlap, R.N., read before the meeting of the Institution of Engineers and Shipbuilders in Scotland, Nov. 7, 1933, abstracted through *Colliery Guardian*, vol. 147, no. 3802, Nov. 10, 1933, pp. 872–873, *pe*)

Fuel Research

THIS report is based on a report of the British Fuel Research Board for the year ending March 31, 1933, published at the end of November. Because it has been already extensively investigated, the production of low-temperature free-burning cokes did not form an important part of the work of the year, but much work was done on the conversion both of low-temperature and high-temperature tars into motor "gasoline" and fuel oils, with particular attention to the latter. By lowering the temperature of the reaction chamber to 430 C, it has been found possible to convert the whole of the product to fuel oil miscible with petroleum fuel oils.

By a reprocessing, low-temperature tar may be converted into its own volume of motor fuel.

It has been established that as the temperature of carbonization is increased, the stability of the tar produced as a raw material for hydrogenation decreases. In addition, the lower the oxygen content of the original coal, the more difficult becomes the treatment of the tars produced at the higher temperatures of carbonization, though at low temperature the difference between the tars from various coals is not so great. This effect is ascribed to the lesser activity of the catalyst in the case of high-temperature tars.

The Fuel Research Station is conducting, also, a general investigation of coal carbonization that is of great interest. The work on pulverized fuel has been particularly directed toward making it available for application in small combustion chambers, and for this purpose three types of short-flame burners have been developed. The investigation of so-called colloidal fuels was continued. It is claimed that for practical purposes absolute stability of the mixture is not essential. An effort has been made to convert the oil into a dilute gel. Such a material flows like normal liquid under ordinary circumstances, but behaves like an elastic solid under small disturbing forces, such as would be called into play in supporting small particles of coal. The gel was obtained by dispersing 0.1 to 0.5 per cent of sodium stearate in refined heavy paraffin oil. A similar gel made by dispersing 0.5 per cent of sodium stearate in Persian fuel oil was used to form a 40-per cent suspension of pulverized coal. It showed no appreciable separation after five months at atmospheric temperature, but began to separate after ten hours at 100 C.

Two suggestions are made in connection with the domestic burning of coal. The first concerns the burning of coal in open grates. Polished aluminum foil may be attached by cement to the back and sides of the grate, and has proved successful when smokeless fuels are employed. The foil increases the radiant heat and improves the appearance of the fire. The foil remains in good condition, and wiping with damp soapy cloth is all that is necessary to remove soot or tar. The second matter relates to the burning of small coal and slack in open grates, and calls to mind the wartime suggestion that the sweepings of the coal cellar should be used for home-made briquets, a small quantity of cement being used as a binder. The present suggestion is that the slack should be packed in paper containers lined with thin aluminum foil. In from 10 to 20 min, on a hot fire, the volatile products burn off and a solid lump of coke remains which burns in the ordinary way. (Report of the Fuel Research Board for the year ending March 31, 1933, abstracted through *Engineering*, vol. 136, no. 3542, Dec. 1, 1933, pp. 604–605, *g*)

GAS ENGINEERING

Comparative Tests of the Vapofier

CONSIDERABLE attention has been attracted to the so-called Vapofier, a device for vaporizing a light grade (No. 1) of fuel oil and mixing this vapor with air, roughly in the correct proportions for combustion. A small portion of the vapor-air mixture is burned in the apparatus itself to supply the heat required for vaporization. The combustible mixture can be carried a limited distance, 20 to 30 ft, in insulated pipe lines and burned in special burners in a manner somewhat similar to gas. This article describes a test between manufactured gas and the Vapofier on a rotary carburizing furnace working on a 24-hr schedule. The test was made at the Philadelphia Gas Works Co. and the details of the test are reported in the original article.

It is stated that the costs of operation are higher with Vapofier than with gas at ordinary rates. It should be noted, however, that apparently the makers of the Vapofier were not represented in the test and did not make or control the installation. (Frank H. Trembly, Jr., Supervisor Industrial Division, Philadelphia Gas Works Co., Philadelphia, Pa., in *Gas Age Record*, vol. 72, no. 24, Dec. 9, 1933, pp. 551–553, *ec*)

HYDRAULICS

Variable Flow of Liquids

THE authors consider cases of the flow of liquids wherein a condition of flow is one of "variable or unsteady flow" and a condition of "dynamic equilibrium" does not exist. For this type of problem the rate of flow and the retarding forces, which are a function of the velocity, vary with time. The authors present a method of analysis of variable and unsteady flow by the direct application of a somewhat new form of the generalized energy equation. This cannot be abstracted in detail here.

The authors derive a special energy equation from the general equations then note that for the course of variable or unsteady flow of incompressible fluids the conditions are the same as those covering the derivation of their special equation, except that there is an accumulation of kinetic energy between the two sections of the conduit at which the conditions of flow are observed. A method of evaluating this equation is then given, from which there is finally derived a general energy equation for variable flow of incompressible fluids. Several applications of this theory to practical problems are then

considered. (Prof. Grant K. Palsgrove and Asst-Prof. Wm. J. Moreland, Jr., Rensselaer Polytechnic Institute Bulletin, Engineering and Science Series, vol. 44, September, 1933, 27 pp., 11 figs., *m*)

INTERNAL-COMBUSTION ENGINEERING

The Effect on Engine Performance of Change in Jacket-Water Outlet Temperature

TESTS made on a Curtiss D-12 engine in the altitude laboratory at the Bureau of Standards show the effects on engine performance of changes in jacket-water outlet temperature:

(1) Friction at all altitudes is a linear function of jacket-water temperature, decreasing with increasing temperature.

(2) The brake horsepower below an altitude of about 9000 ft decreases, and at higher altitudes increases, with increasing jacket-water temperature.

(3) The brake specific fuel consumption tends to decrease, at all altitudes, with increasing jacket-water temperature.

(4) The percentage change in brake power output is roughly equal to the algebraic sum of the percentage change in volumetric efficiency and mechanical efficiency.

As regards the friction in a Curtiss "Conqueror" engine operating at sea level, it was found that it varies approximately linearly with jacket-coolant outlet temperature, the average decrease being 0.33 per cent for each degree increase in temperature. This change in friction horsepower is said to be primarily due to the change in the viscosity of the oil and depends therefore on the viscosity temperature index of the oil. The tendency at all altitudes for the brake specific fuel consumption to decrease with increase in jacket-water temperature is due largely to the increase in mechanical efficiency with increase in jacket-water temperature and to better vaporization of the fuel due to the warming up of the intake manifolds.

In view of the large changes in specific fuel consumption and friction with change of jacket-water temperature, it would seem that the subject deserves further attention. The questions of speed, independent control of intake-manifold temperature, and compression ratio should be studied. The range of altitude pressures and jacket-coolant temperatures should be increased, and tests should be conducted varying the carburetor intake-air temperature with altitude according to the standard atmosphere. It might also be well to conduct the tests with various lubricating oils and jacket coolants. (E. A. Garlock and Greer Ellis, Technical Notes No. 476, National Advisory Committee for Aeronautics, November, 1933, *e*)

LUBRICATION (See also Testing and Measurements: Machine for Testing Lubricating Oils; Moore-Carvin Lubrication Friction Testing Machine)

Used-Oil Tests

IN THE annual report of the Department of Scientific Industrial Research, reference is made to tests now being carried out on used engine oil. A sample was examined that had been in use in a car for 8000 miles. The report states that it was shown that although the used sample gave much lower seizing temperatures than the new sample when first run in the machine, its performance rapidly improved until it was practically equal to the new. The temporary deterioration of the oil appears to be due chiefly to the water which had accumulated during the time it had run in the engine.

This statement opens up a fresh field for investigation, for if deterioration was due to this cause alone, it appears to be quite feasible to provide means of purification from water on the engine, which may mean the reduction of oil consumption to one-eighth of the average amount at present consumed. (*The Automobile Engineer*, vol. 23, no. 312, November, 1933, p. 415, *ep*)

Specifications for Lubricating Oils

IN CONNECTION with a general discussion of reduction-gear sets for main-drive mill motors, the author goes rather thoroughly into the subject of the lubrication of these devices and points out the confusion and costly misunderstandings that result from the adoption of improper specifications.

The type of crude oil from which the lubricating compound is made is the most important factor. There are sharply defined properties which are characteristic of the Pennsylvania, Mid-Continent, Gulf, and Pacific Coast crudes which identify their relative compounds. Oils made from these different crudes can have identical viscosities at 100 F and surprisingly different lubricating values.

Next in importance to the source of crude is the body of the oil. On this property depends the load-carrying capacity or resistance to rupture of the lubricating film. The development of extreme-pressure lubricants has prompted the improvement of this property. The natural body of the oil depends entirely upon the source of the crude. It is possible, however, artificially to strengthen the body by combining the oil with certain inert substances, or through a chemical process of sulphurizing. Whereas such developments require time to substantiate their value, there is every indication that either of these methods produces a decided improvement in the body and load-carrying characteristics of the lubricant without introducing any harmful effects.

Custom has developed the use of viscosity to describe the characteristics of lubricating compounds. This has led to confusion and costly misunderstandings. The viscosity has been specified at one temperature only, usually at 100 F, which, without further elaboration, has introduced a wide difference, both in quality and characteristics.

The intelligent use of viscosity requires its exact specification at no less than two temperatures; namely, 100 and 212 F, and preferably at the expected operating temperature. A first-grade Pennsylvania oil with a Saybolt viscosity of 1560 sec at 100 F will have a viscosity of only 400 sec at 145 F and of 120 sec at 212 F. The properties of this oil and its usefulness as a lubricant will be governed accordingly.

Comparatively high operating temperatures do not harm the gear set itself but they have serious effects on the characteristics of the lubricating compound. Gears are not delicate, nor are they especially sensitive to lubrication. There is no question, however, that their operating performance can be improved materially and their load-carrying capacity increased by maintaining the temperature as low as possible and preserving thereby to the fullest extent the value of the lubricant. There is little information as to the effect of the lubricating stream on the efficiency of a gear set and on its operating temperature. (Austin Kuhns, Mech. Engr., Farrel-Birmingham Co., Inc., Buffalo, N. Y., in *Iron and Steel Engineer*, vol. 10, no. 11, November, 1933, pp. 301–311, illustrated, *d*)

MACHINE PARTS

Piston Rings and Their Relation to Liner Wear

THE most interesting part of this paper deals with sulphur. From the wear standpoint, sulphur is one of the most important of the ordinary impurities present in plain cast iron.

The sulphide is distributed in the form of thousands of hard globules or threads. Given an iron possessing some malleability, plus a structure capable of gripping these globules, then the higher the sulphur the better does the iron wear. The objection is that high-sulphur iron is difficult to manufacture. It has a tendency to go hard and not to be all-pearlitic. In an earlier paper read by the author before this Institute, liners made of iron containing 0.24 per cent sulphur were described. Those liners went into important ships and after all these years the author is able to say that he never made better-wearing ones.

The policy of keeping sulphur as high as possible, without, at the same time, losing strength or acquiring brittleness while maintaining all-pearlitic structure, is sound advice, but it is unpalatable by reason of the difficulty of attainment. Good high-sulphur iron machines easily but cannot be cut by a hacksaw.

The author does not claim to understand the precise effect of manganese and usually keeps it above 1 per cent. In his opinion, the sulphur-manganese balance needs to be maintained, but apart from that the benefits of manganese seem to be negligible. Where heat resistance has to be provided for, the silicon content in the absence of chromium needs to be 1 per cent or less. The author further believes that satisfactory marine-engine piston rings can be made without the use of such alloying elements as chromium, nickel, vanadium, etc. For liner castings, particularly in large sizes, the author has found rare metals useful.

It is the author's experience that wear-resisting properties depend upon structure and upon all-pearlitic structure in particular. There are many types of this structure and not all are alike in wear resistance. The best wearing iron of any one all-pearlitic series is that in which the graphite flakes are disjointed and well distributed, with absence of lines of weakness, and where the pearlitic lamellas themselves are very fine for the thickness and mass of the casting concerned.

The means whereby a desirable structure is attained are simple. Some cast irons possess large graphite and/or large pearlite lamellas at a magnification of, say, 500 diameters, while others will withstand a magnification of 1500 diameters and show no large graphite and no large pearlite lamellas.

As regards dendritic structure, years ago F. Grimshaw Martin, F.I.C., of Alfred Holt & Co., and the author made a study and survey of the Diesel cylinder and liner cast irons of the world. Each worked in his own laboratories, the whole of the results being then brought together and made into a joint report. It is extraordinary that of all those different irons the ones considered to be the better happened to be also the most dendritic. The matter was so obscure that it was decided to do no more than make a note of what had been observed. The subject is no less obscure today.

Among causes contributory to liner wear are corrosion and rust. Impurity of incoming air is important. Compounded oil, particularly from wet compressors and flowing through copper pipes, is bad if carried into the combustion zone.

Lack of continuity of oil-film during starting-up, maneuvering, traffic halts, and so on, is caused by the lubricant's not functioning well under the conditions. Also, and particularly in the case of gasoline engines, dilution with fuel takes place as such times.

Too effective scraper rings, too great unit wall pressure of any ring, or inequality of wall pressure around a ring will cut the oil film, and the harm done perhaps in a moment or so may determine the whole life of the material. Pressure behind rings and lubricant getting up into the combustion zone are two problems which various inventions appear to alleviate.

Several other causes are enumerated. The author comes to the conclusion that ordinary marine piston rings for large superheat and Diesel jobs give little trouble, but the situation in high-speed compression-ignition engines calls for improvements in materials and the manner of producing the rings.

As regards materials the author mentions an iron called "Vacrit" containing chromium, vanadium, and titanium. It is cast in dry-sand molds in the ordinary way and is not heat-treated either in the mold or later. The author then mentions the matter of scraper rings, sealing rings, gap clearance, unit wall pressure, etc. (H. J. Young, Hepworth & Grandage, Ltd., paper before *The Institute of Marine Engineers*, abstracted from proof copy, vol. 44, no. 12, 1933, 10 pp., 10 figs., *p*)

MARINE ENGINEERING (See Fuels and Firing: Liquid Fuels From Coal for Navy Purposes)

METALLURGY

"Durapid" Process of Case-Hardening

IN THIS process, developed by Professors Budowski and Bardt, the pieces to be case-hardened are covered by a semi-liquid base and then heated in an ordinary muffle furnace to a temperature varying from 880 to 950 C (1616 to 1742 F) according to the character of the steel and the depth of case desired.

The pieces are then dipped in a special bath of complex character having approximately the same physical characteristics as mineral oil. Soft steel or steel containing up to 2 per cent of nickel is additionally cooled by immersion in water after an immersion of a few seconds in the special bath. It is claimed, however, that the process costs less to operate than either the cyanide hardening or nitriding. (*Aciers Speciaux, Metaux & Alliages*, vol. 8, no. 94, June, 1933, pp. 192–196, 2 figs., *d*)

Influence of Beryllium on Steel

IN MECHANICAL ENGINEERING, Vol. 55, No. 11, November, 1933, p. 699, there appeared an abstract of a paper by J. H. Dickenson and Dr. W. H. Hatfield at the meeting of the Iron and Steel Institute at Sheffield on Sept. 14, 1933. In this paper it was reported that a limited number of tests on steels containing nickel and carbon have shown that beryllium does not improve the mechanical properties of the steels tested, but produces an increased hardness in the steels, and in the case of 18-8 stainless steels, unfavorably affected the corrosion resistance. In the present publication the author points out that previous publications, such as those issued by the Siemens Co., in Berlin, indicated that additions of beryllium to nickel-free steels result in a brittle alloy. The binary beryllium alloys have a coarse structure similar to that of phosphoric iron and it is necessary to add at least 5 per cent of nickel to a one per cent beryllium-iron alloy to obtain a fine grain. One per cent beryllium in the presence of an adequate quantity of nickel is quite equal in its hardening properties to the addition of one per cent of carbon.

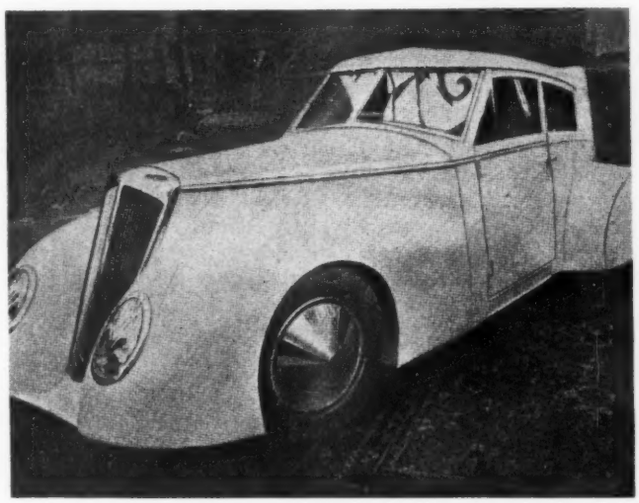
The author calls attention of steel metallurgists to a property of beryllium which he claims to be new, namely, that it brings about age-hardening in carbon-free iron. This enables articles to be machined in the soft state after quenching. They can then be hardened as effectively as carbon steels by a comparatively low temperature treatment. This property has not yet

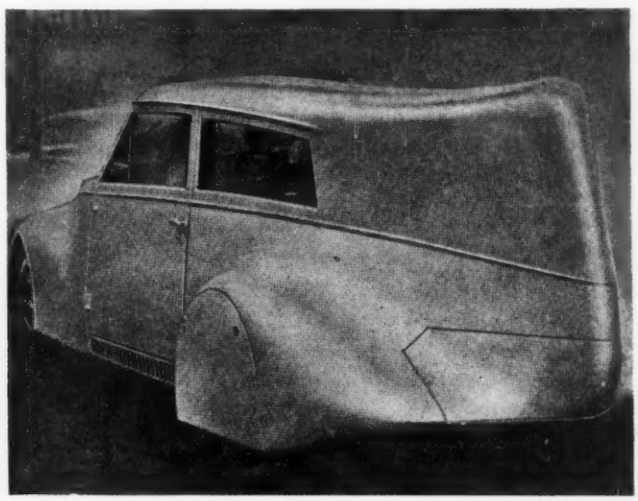
been adopted in manufacturing practise. The author claims also that beryllium is an extremely good scavenger for steel and can completely eliminate sulphur. (Dr. W. Kroll in a letter to *Engineering*, vol. 136, no. 3543, Dec. 8, 1933, pp. 634–635, *dp*)

MOTOR-CAR ENGINEERING

Streamlined Automobiles

AMONG the cars shown at the Paris Automobile Show may be mentioned two of the Mistral units as carrying the idea of streamlining to what appears to be the ultimate possible extent. In the Chenard-Walcker-Mistral sedan, Fig. 1, a wedge-shaped radiator shell is mounted well forward and has a considerable rake. At each side of it the side panels of the hood sweep out over the wheels to form fenders extending right over in front of the wheels and finishing in a straight edge parallel with the ground. The wheels are therefore completely enclosed except at the sides, and the overhang at the front is sufficient for the headlights to be mounted in the fenders themselves. The fish-shaped tail and streamlined fenders of the Mistral sedan are shown in Fig. 2. The rear fenders are formed by an outward sweep of the body side panels, and the wheels are enclosed at the sides by panels which can be detached for wheel changing. (*The Automobile Engineer*, vol. 23, no. 312, November, 1933, pp. 399–410, 39 figs., part referred to in this abstract on p. 407, *d*)





FIGS. 1 AND 2 LEFT—CHENARD-WALCKER-MISTRAL STREAMLINED SEDAN; RIGHT—FISH-SHAPED TAIL AND STREAMLINED WINGS OF THE CAR SHOWN ON THE LEFT

POWER-PLANT ENGINEERING (See also Fuels and Firing: Evaluation of Fuels for Boilers and Gas-Producer Operation)

The Yallourn Power Station, Australia

THIS power station, which was intended for generation of electricity from low-grade lignites, was briefly described in MECHANICAL ENGINEERING, Vol. 51, No. 2, February, 1929, pp. 150–152.

The undertaking now in efficient operation has had a checkered and difficult career. The plant was designed to handle lignite averaging 48 per cent moisture because this was the moisture content in lignite from one section of the area investigated. Later on, however, it was found that the plant would have to burn lignite containing from 62 to 66 per cent moisture, an entirely different proposition. It was also found that wrong methods of mining, conveying, and burning the lignite were adopted, rendering operation with such a low-grade fuel far too costly. This was all the more surprising as lignite of approximately the same character has for years been burned successfully under steam boilers in Germany. It was only after several years of struggle with the difficulties encountered that the officials of the State Electricity Commission decided to install modern German lignite mining and conveying equipment.

The former practise of screening raw lignite before burning has been discontinued and equipment for burning the lignite direct without screening has been adopted from Germany. The existing traveling-grate stokers have been greatly modified, new types of pre-drier invented, and German step-grate stokers more suitable for raw lignite installed.

In addition to the power station at Yallourn there is an extensive lignite-briquet factory which has now a maximum capacity of 1200 tons of briquets per 24 hr. This is also operating on the latest German principles using presses of the "sausage" or extrusion type. The details of the plant are given in the original article. (David Brownlie in *The Steam Engineer*, vol. 3, no. 3, December, 1933, pp. 101–104, illustrated, *d*)

Atmos Revolving Tube Boiler

THIS boiler was invented by a Swedish engineer, Victor Blomquist, and described in MECHANICAL ENGINEERING, Vol. 51, No. 5, May, 1929, p. 379.

The first stage was the high-speed type, consisting of a series of horizontal evaporator tubes running at 300 to 350 rpm. In 1928 this was modified to the squirrel-cage design consisting of a series of interconnected horizontal evaporator tubes joined to flat circular header plates at each end to form a squirrel-cage type of steam generator. The speed of the squirrel cage is only about 20 rpm. During the past 18 months, the third type was evolved to be known as the internally fired squirrel cage. This type has a cage containing a much larger number of hori-

zontal evaporator tubes—as many as 90 or more—with the fire inside the cage itself, thus eliminating the firebrick combustion chamber and requiring only a light outer casing. The idea of a revolving cylindrical furnace is not new, but a combination of a steam generator and a furnace of this type is claimed to be new. The principle of the squirrel-cage design is briefly explained in the original article.

The plant of the Alsatian Company of Mechanical Constructions at Mulhouse consists of two standard squirrel-cage tube rotors operating at 1560 lb per sq in. pressure and 840 F superheated steam temperature, with an evaporation of 22,000 to 30,850 lb of water per hr. They are fired with pulverized coal on the "unit" system with two burners—one for each squirrel cage. The steam is used to drive a back-pressure turbine which exhausts at 176 lb per sq in. to the existing circuits of the Mulhouse factory, thereby generating 750 kw by the drop in the pressure.

It is stated that the original Atmos boiler installed at the Fors Bruk pulp mill in Sweden has been converted into the squirrel-cage principle, giving a boiler plant efficiency of 84 per cent without air heaters. Whether the internally fired squirrel-cage boiler has been actually built, at least in commercial sizes, is not clear. The original article gives, however, diagrammatically horizontal and end sections of this type of volume. (*Engineering and Boiler House Review*, vol. 47, no. 6, Dec., 1933, pp. 366–368, 3 figs., *d*)

Sodium Aluminate as an Adjunct to Lime-Soda Feedwater Treatment

THE author tells of a case of three water-tube boilers where, from improperly treated feedwater, extensive corrosion was found in the drums. This was so serious in certain parts of the drums that the boiler inspector had periodically to have the plates drilled to ascertain their thickness and the working pressure had been reduced from 200 to 150 lb per sq in. Yet the crude feedwater was treated in a lime-soda softening plant and about 50 per cent of the feed consisted of returned condensate. The crude feedwater was hard but otherwise quite good for boiler-feed purposes. The analysis of the crude water showed a fair amount of magnesium salts. During treatment the magnesia was precipitated as magnesium hydrate by the action of the lime and soda. This magnesium hydrate was of a very light flocculent nature and its removal by sedimentation was a difficult matter. This, together with the exhaust steam passing into the reaction tank causing considerable agitation, resulted in the removal of very little of the deposited salts before the water reached the wood-wool filters.

It appeared, therefore, to be necessary to adopt some means of coagulating the precipitated salts so as to help both the settling and the filtration. Sodium aluminate was adopted for this purpose, and the desired results were obtained almost immediately, viz., the water leaving the wood-wool filters was absolutely clear. In order to prove definitely that the results were brought about by the sodium aluminate, this chemical was discontinued for a short time, and very soon the feedwater became "milky" and contained a fair amount of very finely divided particles of suspended matter. When the sodium aluminate was again used, the desired clear water was obtained. A solution of sodium aluminate in water was introduced into the crude water by a special automatic discharge-measuring apparatus with the milk of lime and soda solution. This insured that the correct feed of aluminate was maintained. The quantity tried at first was 1/4 lb of sodium aluminate per 1000 gal of water, as recommended by the suppliers. It was found, however, that this should be cut down by 50 per cent, but had to be increased to the amount used at first when a bigger supply of steam was required and a correspondingly larger amount of water treated.

Details as to sodium aluminate are given in the original article, where a chart is given showing, among other things, the advantage of using a water with a lower alkalinity, providing the hardness does not rise; and it is the experience of the author that the concentration of the total dissolved solids may be permitted to be very much higher when the alkalinity of the boiler water does not exceed, say, 70 deg (to methyl orange).

While the cost of sodium aluminate is high compared with such reagents as lime and soda, the small quantity necessary in most cases, as stated, adds very little to the cost of the water treatment. (C. N. Ridley, *The Steam Engineer*, vol. 3, no. 3, December, 1933, pp. 105–107, 1 fig., *d*)

Sulzer Single-Tube Steam Generator

THIS generator consists of a continuous tube in which the feedwater is preheated and evaporated and the resulting steam superheated. Increase in volume of the water and steam raises the velocity of flow in such a way that it is quite impossible for steam bubbles to remain on the sides of the tubes and heat transmission is considerably improved. The superheat temperature is said to be strictly under control and the working medium to pass from one state into the next without any trouble, even when the load on the boiler fluctuates greatly and suddenly. The counterflow principle is used, which means that the feedwater is introduced where the flue gases leave the generator and evaporator, and superheating takes place where the tube is subjected to radiation from the burning fuel. The matter of regulation is discussed in detail. This is based on the principle that the regulating device is made to function when the final steam temperature exceeds or falls below the normal temperature by a certain amount. It is not only the excess temperature which is used to determine when regulation shall be effected but also the differential quotient of that excess with regard to time. When the total load on the boiler increases, the intensity of the firing must be increased as well as the quantity of feedwater delivered. The rate of steam raising, the intensity of firing, and the quantity of feedwater are, however, all functions of each other. In this case the regulating arrangement employs hydraulic control and hydraulic remote transmission and is described in detail in the original article.

Among other devices used is an injection regulator with isothermal compensating motion and a "pulsator," a device for maintaining a continuous slight fluctuation in pressure in all parts of the regulating device. The oscillation of all movable parts constantly caused in this manner makes them respond more quickly to the slightest change in the mean pressure and almost entirely eliminates the risk of the seizing of any member.

Where importance is laid on the closest regulation even with great and sudden fluctuations in load, a special arrangement is provided. (Prof. A. Stodola, of Zurich, in serial article in *The Engineer*, vol. 156, no. 4062, Nov. 17, 1933, pp. 496–500, 14 figs., *d*)

RAILROAD ENGINEERING

Statistics on Broken Rails

IT IS STATED that according to a report of the American Railroad Engineering Association a total of more than 37,800 enforced rail replacements were made in the United

States in a single year, which is said to represent 22,000 tons of rails, or 2 per cent of the total rail tonnage rolled for American railroads in 1931, and 6 per cent of the 1932 tonnage.

During 1931, in America, 251 derailments were caused by broken rails. Similar statistics, but more detailed in description, were presented to the last International Railway Congress and appear in summarized form in the Bulletin of the International Railway Congress Association. These statistics were supplied by only one British railway, The London and Northeastern, and by France, Czechoslovakia, and Roumania, no figures having been supplied from Germany and America, so that a full comparison is not possible. It is noted, however, that, whereas on the London and Northeastern Railroad in 1931 the total rail fractures averaged 2.5 per 1000 km of tracks, in France they averaged from 9.5 to 44.9 per 1000 km and in Czechoslovakia and Roumania from 71.5 to 97 per 1000 km. This is ascribed by the British publication, *The Railway Engineer*, to the character of the British steel manufacture and efficiency of railroad inspection methods in Britain. Transverse fissures caused no failures on the London and Northeastern, but fissuring and piping together were responsible for roughly one-third of the Continental fractures. (Editorial in *The Railway Gazette*, vol. 59, no. 20, Nov. 17, 1933, p. 719, *c*)

REFRIGERATION

Activated Ice

THE Katadyn process for the sterilization of water by means of metallic silver described in MECHANICAL ENGINEERING, Vol. 52, No. 6, June, 1930, p. 626, has recently been applied to the production of artificial ice. It is important to have the ice sterile wherever it is intended for human consumption or comes in contact with foodstuffs. It is comparatively easy to produce sterile ice from sterilized water, but after being manufactured the ice is likely to be infected on the way from the factory to the user. It is claimed, on the other hand, that artificial ice made from water treated by the Katadyn process not only is sterile, but in addition has bactericidal properties. Investigations at the Hygienic Institute of the Dresden Technical University have proved that germs introduced into the melting water at 0 C (32 F) of activated ice were killed after a few hours.

To produce activated ice it is necessary to dissolve in the water a very slight amount of metallic silver. A few decigrams per cubic meter of water will suffice (1 decigram per cu m = 0.007 grain per Imperial gal). The water is activated by passing a feeble electric current through it from silver electrodes. The activator, a small vertical cylinder of strong construction, is inserted in the water pipe; it takes up very little room and requires no attention to speak of, attendance being confined to watching the switchboard. The operation of the ice-making plant is in no way influenced by this preliminary treatment of the water, and there is no difficulty whatever in installing a plant to manufacture activated ice by means of the Katadyn process in any existing ice plant.

The current consumption of the Katadyn installation is insignificant, likewise the silver consumption. In a plant with a daily production of 150 tons of ice, the current consumption in a year will only be about 20 kwhr. The silver electrodes are so dimensioned that they need be replaced only once a year. Some 225 tons of activated ice are produced today by the Linde Company in their ice factory in Dresden. (*Engineering Progress*, vol. 14, no. 11, November, 1933, p. 215, *d*)

TESTING AND MEASUREMENTS

Machine for Testing Lubricating Oils

THIS is a description of the Spindel machine for testing oils, Fig. 3, built by the Augsburg-Nürnberg Machine Co. in Germany.

In this machine *a* is a hollow sheave, *b* the axis of the oscillating frame and the hollow sheave, *c* space for locating an electric heater, *d* the body being tested, *e* indicator of temperature of the body being tested, *f* load on the body being tested, *g* lever between *d* and *h*, the latter being the oscillating frame, *i* oil bath, and *k* indicator (visual and registering) for the friction developed. The hollow sheave *a* is made of hardened steel and during tests for high specific pressures is immersed in the oil bath to a depth of about 10 mm (0.4 in.). The body to be tested is made of the material in connection with

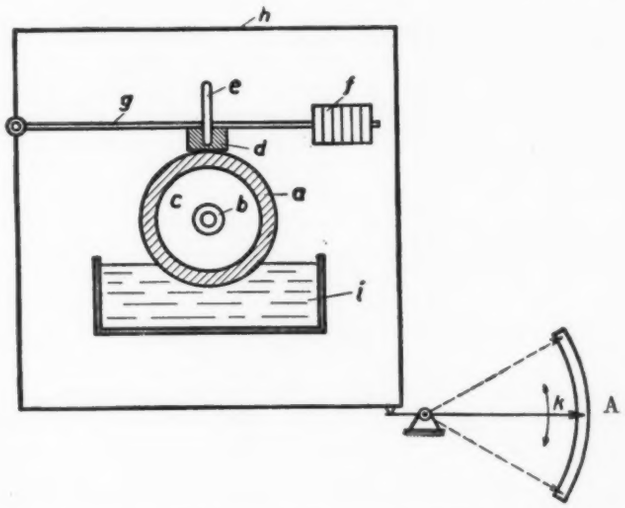


FIG. 3 DIAGRAMMATIC VIEW OF THE SPINDEL OIL-TESTING MACHINE FOR TESTING LUBRICATING OILS, INDICATING ITS ESSENTIAL ELEMENTS AND PRINCIPLE OF OPERATION

which the lubricating properties of the oil are to be determined.

The heat developed by the friction is specially shown on an appropriate measuring device. The original article reproduces graphically the result of frictional resistance of various lubricating oils.

The body to be tested is connected by a lever and joints to a heavy oscillating frame. This frame takes the vertical position when the machine is at rest and the registering indicator connected therewith (Fig. 3) reads zero, that is, when the friction between the hollow sheave and the body to be tested is zero. As soon, however, as the sheave begins to rotate, more or less friction is produced by the sheave and the body to be tested, and the oscillating frame correspondingly moves out of its zero position, thus affecting the readings of the indicator.

It is stated that testing oil for steam engines and internal-combustion motors at high temperatures is of particular interest, and the results of tests have shown how greatly different is the behavior at high temperatures of oils which have approximately the same ability to lubricate at low temperatures. Moreover, very different properties of lubrication show up at different velocities of sliding between the two bodies. (*Chemiker-Zeitung*, vol. 57, no. 79, October 4, 1933, pp. 782–784, illustrated, *d*)

Moore-Carvin Lubrication Friction Testing Machine

THE instrument consists of a 3-hp shunt motor with steel journal *B*, Fig. 4, keyed to the shaft. This journal forms the test bearing shaft, and is 1.9 in. in diameter. The surface is of high carbon steel, ground to a high even polish, and is practically a perfect cylinder at the bearing surface. A brass collar *C*, with 1.904 in. inside diameter, is fitted over the journal, supported by the lug *E* on the lever arm so that it floats freely on the journal.

This collar supports the bearing plugs *D* and also is the means of applying lubricant to the shaft between shaft and bearings. The bearing plugs are 0.75 in. in diameter, and may be made of any bearing metal which is desirable to employ. The bearing surface of the plugs is machined to the same diameter as the shaft, and before being used for experimental purposes, is "run in" to a smooth fit and high polish. The plugs are

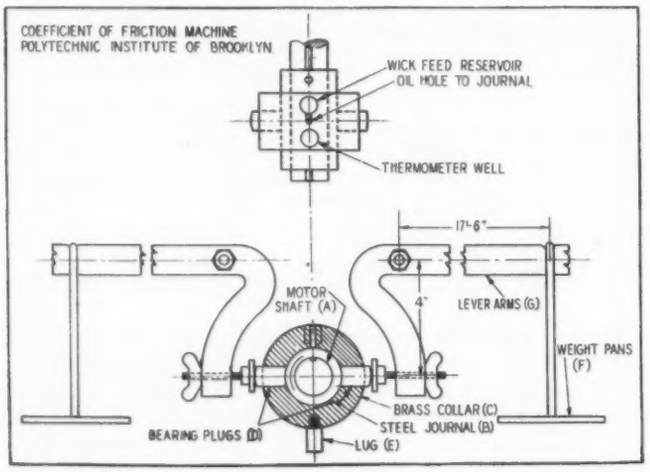


FIG. 4 MOORE-CARVIN LUBRICANT FRICTION-TESTING MACHINE

supported by the lever arms *G*, and pressure on these plugs may be adjusted by weights placed on the pans *F*.

By calculating the mechanical advantage of this lever, and from the bearing area of the plugs, the pressure per square inch on the plugs may be varied by definite increments by using weights of proper mass.

The coefficient of friction is determined by observing the power required to drive the motor when the plugs are pressing against the shaft under the stipulated conditions. The details of the method of calculation are given in the original article. Among other things studied by means of this machine was the change in coefficient of friction with change in the properties of lubricants, particularly the reduction of the coefficient of friction when mineral oil is oxidized, and the action of the fatty acids and fats in promoting a higher film strength in lubricants and in reducing friction coefficients at high bearing pressures. Reference is made to the action of blending materials not otherwise specified. (*National Petroleum News*, vol. 25, no. 46, Nov. 15, 1933, pp. 35–39, 5 figs., *d*)

TEXTILE MACHINERY

Cloth Like Glass

CLOTH which has the appearance of glass has been developed by Lustre Printers, Ltd., Gorton, Manchester, England. Designs in colored glass can be applied without laborious handwork to velvet, silk, lace, cotton, and fabrics of all kinds, imparting to them the attraction of a diamanté-studded gown. Experiments have been going on for months in Manchester and they have now reached a stage that justifies actual manufacture. The new product is expected to prove an asset in Lancashire's battle against Japanese competition. The makers of the new cloth use a synthetic glass which allows the cloth to be washed or ironed without damage to its design. The cloth to be printed is simply passed through a machine which indelibly impresses on it any design that is wanted. The firm has also applied the process successfully to the new transparent cellophane-like paper, which is being manufactured in large quantities in Lancashire. (*Industrial Britain*, no. 16, December, 1933, p. 5, *d*)

Tube-Tex Machine

THIS machine, made by H. W. Butterworth and Sons Co., of Philadelphia, extracts, processes, dries, finishes, conditions, and measures tubular knit goods, all in one continuous operation. It employs only three operators and, it is claimed, can process and finish from 2800 to 3000 lb of fabric in 8 hr. A wide range of desirable finishes can be obtained. The moire is eliminated and losses at the end of the rolls are reduced to not more than 3 in.

It is claimed that the goods can be taken from the dye kettle and finished in roll form in 5 min. Because of the lack of space the details of the machine are not given here. It may be stated, however, that the fabric is taken directly from a dye beck and passes through pot eye guides. It is then opened up fully by a driven spreader which is really the heart of the machine. It is next passed under the immersion roll and then through squeeze rolls. If finish is required, the proper liquid may be poured over the goods at the top of the squeeze rolls, squeezed, and then allowed to run down to the immersion pans from which it is recirculated.

According to the present article: "The fabric is carried through a drier, free from tension at all times, except where tension is applied by spreader units. There is a mechanism which insures uniformity; tension being applied to the fabric as it emerges from the drier, and before it passes to the final finishing machine."

In the finishing machine the fabric is steamed twice and opened up by the driven spreader between the steamings. It then goes to the finishing rolls and before being wound up is cooled by a process which insures that a proper amount of moisture is left in the fabric. (*Rayon*, vol. 14, no. 11, November, 1933, pp. 41 and 40, *d*)

THERMODYNAMICS

Tests on the Transmission of Heat in Air Coolers

THE article describes the experimental apparatus used and methods followed. The results are not considered to have universal practicability because of certain imperfections in the processes used. It is believed, however, that their value lies rather in the fact that they give coefficients of heat transfer which could be used for purposes of comparison with values of dew points obtained under the same conditions of flow and thereby make it possible to check on the Lewis theory. The coefficients of heat transfer which they have found can be expressed by the equation $\alpha = 0.00130\ Re_w^{0.9}$ in kcal per sq m per hr (1 kcal per sq m per hr = 0.368 Btu per sq ft per hr). In this equation Re_w is the Reynolds number denoting the state of the air corresponding to a given temperature of wall, and the original article gives a table of values for α for values of Re_w varying from 13,000 to 80,000.

The author proceeds next to a consideration of dew tests. The results of these tests are given in the form of curves.

The data were evaluated on the basis of Merkel's theory (*Zeitschrift für die Gesamte Kalte-Industrie*, 1927, p. 118). This theory assumes Dalton's law to be valid in accordance with which the amount of condensation or dew is proportional to the partial fall of pressure from the mixture to the wall. As it is impossible to measure the temperature of the water surface in drop condensation (which method was used in the present case), a state of saturation corresponding to the temperature of the wall was used. In this way an equation for the dew coefficient has been determined and presented in the original article. (G. Hase in *Zeitschrift für die Gesamte Kalte-Industrie*, vol. 40, no. 10, Oct. 9, 1933, pp. 149–154, 6 figs., and a table occupying nearly a page, *t*)

Equation for the Determination of the Coefficient of Heat Transfer From a Fluid in Turbulent Flow to the Wall of a Tube

THE author gives a brief review of the previous work on the subject, including that of Merkel. The Heater Conference of the Soviet Union recommended in February, 1932, to give this latter equation the following form

$$Nu = CRe^{0.435}\ Pe^{0.435} \quad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where $Nu = \frac{\alpha d}{\lambda}$ is the Nusselt number, $Re = \frac{wd\rho}{\eta} = \frac{wd}{\nu}$ is the Reynolds number, $Pe = \frac{wd}{a}$ is the Peclet number, and C is a constant depending on the units in which the other factors are expressed. The following notation is used: α = coefficient of heat transfer from the liquid to the wall, kcal per sq m per hr per deg C temperature difference = 0.204 Btu per sq ft per hr per deg F temperature difference; λ = coefficient of heat conductivity of the liquid, cal per m per hr per deg C temperature difference = 0.64 Btu per ft per hr per deg F temperature difference; ρ = density of the liquid in kg per sec^2 per m^4 = γ/g, where γ is the specific weight of the liquid, kg per cu m or 0.062 lb per cu ft, and g is acceleration due to gravity, 9.81 m per sec per sec, or 64.8 ft per sec per sec; η = coefficient of absolute viscosity of the liquid, kg-sec per sq m; ν = coefficient of kinematic viscosity of the liquid in m^2 per sec; a = coefficient of temperature conductivity of the liquid, expressed as the ratio of the coefficient of heat conductivity of the liquid to the product of heat capacity of the liquid at constant pressure times the specific weight of the liquid; w = velocity of flow of the liquid, m per sec; d = inside diameter of the tube, meters; and L = length of the tube, meters. The author proceeds then to the consideration of the Kraushold equation in *Forschung aus dem Gebiete des Ingenieurwesens*, vol. 4, no. 1, Jan.-Feb., 1933, pp. 39–44, where Kraushold offers the following equation:

$$Nu = 0.024Re^{0.8}\ Pr^{0.37} \quad \ldots\ldots\ldots\ldots\ldots [10]$$

in which Pr (Prandtl's criterion) = $Pe/Re = \nu/a$.

The author attempted to modify Equation [10] so as to make it more convenient for purposes of calculation and collected the data of the most reliable values for the various items going into the equation. He illustrates it by way of diagrams and nomograms. The interest of his tables of physical constants for water (Table 1) lies in the fact that he has carefully gone to the original sources and selected those which appeared to be most reliable. The heat capacity of water c_p in calories per kg per deg C were taken from Dieterici, 1905. The specific weight of water γ in kg per cu m was taken from the work of Thiessen, 1900, 1909, 1918, and Chappuis, 1907. The values for absolute viscosity of water were taken from the International Critical Tables, Vol. 5, 1929, p. 10, while the values in the range from 100 to 160 C (212 to 312 F) were taken by Heydweiller, 1886. Only values up to 160 C (320 F) for the viscosity of water have been taken as no experimental values for the higher ranges are available. In the diagrams, however, values of viscosity have been extrapolated to 200 C (392 F). The values in the International Critical Tables are given in millipoise units and have been converted to kilogram-seconds per square meter units according to the following formula:

$$\eta\ (\text{kg-sec per sq m}) = \frac{1}{98{,}100}\ \eta\ (\text{millipoises}) \quad \ldots\ldots [11]$$

TABLE 1 BASIC PHYSICAL CONSTANTS FOR WATER

Temp, deg C	Heat capacity, c_p	Specific weight, γ	Heat conductivity, λ	Absolute viscosity, $10^6\,\eta$	Kinematic viscosity, $10^7\,\nu$	Coef temp cond, $10^7\,a$	Prandtl's criterion, $Pr = \nu/a$
0	1.0088	999.87	0.477	182.9	17.95	1.314	13.66
10	1.0021	999.73	0.495	133.5	13.10	1.372	9.54
20	0.9987	998.23	0.513	102.8	10.105	1.429	7.07
30	0.9984	995.67	0.529	81.6	8.04	1.478	5.44
40	0.9987	992.24	0.543	66.6	6.59	1.522	4.33
50	0.9996	998.07	0.554	56.0	5.56	1.558	3.57
60	1.0008	983.24	0.564	47.9	4.78	1.592	3.00
70	1.0025	977.81	0.570	41.5	4.16	1.615	2.58
80	1.0045	971.83	0.576	36.4	3.67	1.639	2.24
90	1.0070	965.34	0.582	32.3	3.28	1.663	1.97
100	1.0099	958.38	0.586	28.9	2.96	1.682	1.76
120	1.0170	943.4	0.589	23.7	2.46	1.705	1.44
140	1.0257	926.4	0.589	20.0	2.12	1.722	1.23
160	1.0361	907.5	0.587	17.7	1.92	1.734	1.11

As regards λ, heat conductivity of water, the author refers to Jakob's formula of 1920. In the past it has been assumed that the heat conductivity increases with the temperature in accordance with the straight-line law at temperatures up to 200 C (392 F). The recent experimental investigation of Schmidt and Selschopp (*Forschung aus dem Gebiete des Ingenieurwesens*, Vol. 3, No. 6, Nov.-Dec., 1932, pp. 277–286) carried in the range of temperatures from 8 to 270 C (46.4 to 518 F) showed that this assumption is erroneous and that the heat conductivity of water varies with the temperature not in accordance with the straight-line law, but in accordance with a parabolic law. It exhibits a clear maximum at 130 C (266 F) and returns to 270 C (518 F) to approximately the same value as at 0 C (32 F). Schmidt does not publish the equation of the parabola governing the heat conductivity values, but it is clear that Jakob's equation, particularly at temperatures of water above 70 C (158 F), may lead to considerable errors.

To make computations more convenient the author expresses Equation [10] above, as follows:

$$\alpha = 0.024\ \frac{\lambda}{\nu^{0.8}}\ Pr^{0.37}\ \frac{w^{0.8}}{d^{0.2}} = A\ \frac{w^{0.8}}{d^{0.2}}$$

(cal per sq m per hr per deg C) $\ldots\ldots [13]$

where A is the coefficient depending exclusively on the temperature. This coefficient can be computed from Equation [1] and its values are given in a curve and table. In the latter, the values of A have to be multiplied by a coefficient K depending on the diameter of the tube and the values for K are given in an additional table. The value of A varies with the temperature of water practically exactly in accordance with the parabolic law:

$$A = 1190 + 21.5t - 0.045t^2 \quad \ldots\ldots [14]$$

TABLE 3 COEFFICIENTS OF HEAT TRANSFER FROM WATER TO TUBE WALL

(According to modified Kraushold Equation [13])

w, m per sec	Temperature, deg C 20	40	60	80	100	120	140	160
0.2	940	1,165	1,370	1,550	1,720	1,855	1,975	2,045
0.3	1310	1,620	1,900	2,150	2,380	2,575	2,740	2,840
0.4	1640	2,035	2,390	2,705	2,990	3,240	3,450	3,570
0.5	1955	2,425	2,845	3,220	3,565	3,860	4,110	4,260
0.6	2260	2,800	3,300	3,730	4,120	4,460	4,750	4,925
0.7	2560	3,175	3,730	4,220	4,660	5,050	5,380	5,575
0.8	2855	3,540	4,160	4,700	5,200	5,630	5,980	6,210
0.9	3140	3,900	4,580	5,175	5,725	6,200	6,600	6,830
1.0	3408	4,236	4,968	5,620	6,213	6,730	7,155	7,420
1.2	3940	4,890	5,750	6,500	7,200	7,780	8,275	8,570
1.4	4450	5,520	6,400	7,330	8,110	8,780	9,350	9,700
1.6	4970	6,160	7,250	8,200	9,060	9,810	10,450	10,830
1.8	5450	6,760	7,950	9,000	9,950	10,750	11,480	11,890
2.0	5930	7,360	8,650	9,780	10,830	11,700	12,480	12,900
2.2	6405	7,960	9,350	10,580	11,700	12,650	13,470	13,950
2.4	6875	8,530	10,000	11,310	12,520	13,550	14,420	14,930
2.6	7330	9,100	10,700	12,090	13,370	14,450	15,400	15,950
2.8	7760	9,640	11,330	12,800	14,170	15,310	16,310	16,900
3.0	8220	10,200	11,950	13,510	14,980	16,200	17,250	17,850

The above magnitudes should be multiplied by the following values of K to take care of the influence of the diameter d of the tube:

d (mm) =	10	14	18	22	26	30	34	38	42	46	50
K =	1.173	1.097	1.040	1.00	0.977	0.941	0.917	0.896	0.880	0.863	0.850

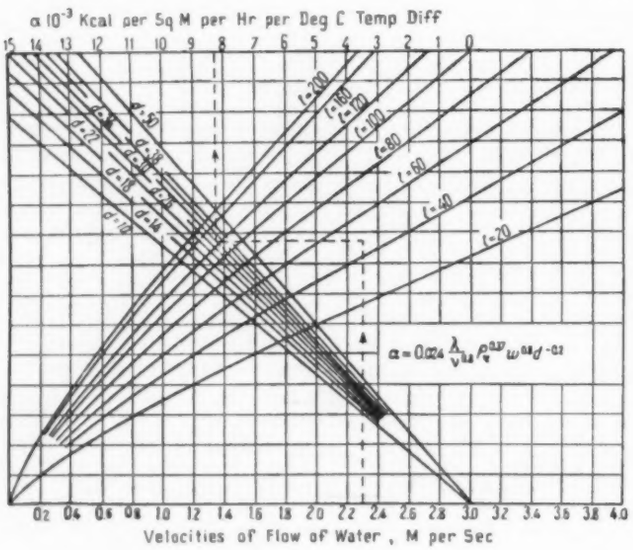


FIG. 5 NOMOGRAM FOR DETERMINING THE COEFFICIENT OF HEAT TRANSFER FROM WATER IN TURBULENT FLOW TO TUBE WALL, ACCORDING TO KRAUSHOLD MODIFIED EQUATION [13]

The deviation from the exact values of A derived from the table and the approximate values derived from Equation [14] are shown by Table 2, in the original article, to be within one per cent at two or three points and less than one-half of one per cent at all other points. This makes it possible to express the Kraushold Equation [10] in the following greatly simplified form:

$$\alpha = (1190 + 21.5t - 0.045t)^2 \frac{w^{0.8}}{d^{0.2}}$$

(cal per sq m per hr per C).....[15]

Table 3 gives the values of α.

This makes it possible to construct Fig. 5 for the determination of the coefficient of heat transfer from water in turbulent flow to the wall of the tube. The nomogram is very simple and convenient. First, the velocity of the water in meters per second is laid off on the abscissas. An ordinate is then drawn at right angles to the abscissas to the point of intersection with the curve of t = constant. The horizontal is then drawn to the intersection with the straight line d = constant, whereupon the vertical line is drawn to the scale α.

It is still somewhat questionable what temperature should be considered in calculating the coefficient of heat transfer. Some authors claim that the temperature of the tube wall exerts the greatest influence on the heat transfer, while others assign the major influence to the temperature of water. Since the matter is open and the more or less correct determination of the temperature of the tube wall or the true average temperature of the water is difficult, the author suggests using the determinable average temperature of the water.

This gives values pretty close to those obtained with either of the previous views as a basis. The author compares the values of the equation of Kraushold, Merkel, and Ten Bosch and finds that the former gives lower values for the coefficient of heat transfer than Merkel's equation, and that with the increase in temperature, diameter, and velocity of flow the difference between the two groups of values increases and may go as high as 10 to 14 per cent. The difference between the Kraushold and Ten Bosch equations is of the same sign but of lower magnitude, namely, 0 to 5 per cent. (E. P. Shoobin and C. F. Kopyeff in *Proceedings of the Soviet Union Thermodynamic Institute*, no. 8 [86], 1933, pp. 35–38, 4 figs., 3 tables, *tA*)

Influence of Superheating of Steam on Heat Transfer

THE author claims that there is as yet no agreement among students of thermodynamics as to the effect of superheat of steam on heat transfer. In 1925 W. Stender showed by calculation that the coefficient of heat transfer from superheated steam condensing on a wall is the same as from saturated steam. His calculation, however, was made on the assumption that the heat of superheat is carried away simultaneously along the entire surface and that condensation of the superheated steam and undercooling of the condensate take place. Should such a situation exist, condensing superheating steam would naturally behave like saturated steam and there is no question about that. It is, however, questionable whether the assumptions on which Stender built up his calculations apply in all cases, particularly under conditions which prevail in practical evaporation and heating. This the author of the present article denies and says that in practise a reduction in the amount of transfer of heat when highly superheated steam has been used, has been proved. This circumstance, and in particular, tests made by Röcke, led M. Jakob to look for an explanation of this difference. He finds it among others in the fact that one of the assumptions of the Nusselt theory is not satisfied, namely, that the water on the steam side of the wall has the saturation temperature. This, according to Jakob, can be true when the greater part of the saturated steam molecules attacking the water film are not condensed but rebound after a small amount of cooling, just as a hot gas is cooled only very little, along a cold film of liquid. However, Jakob does not attach any particular importance to this defect of the assumptions underlying the Nusselt theory.

The present author believes that another explanation can be presented for the fact that there is a delay in the heat transfer in the case of highly superheated steam, at least in so far as particular heat exchangers are concerned. In such heat ex-

changers coefficients of heat transfer of 3000 kcal per sq m per hr per deg C (1 kcal per sq m per deg C = 0.204 Btu per sq ft per hr per deg F) are quite high at temperature differences of 5 to 10 deg C (9 to 18 deg F) for outputs of 15,000 to 30,000 kcal per sq m per hr (1 kcal per sq m = 0.368 Btu per sq ft per hr).

As a rule, in the first stages of evaporators, which are the only ones that need be considered in connection with the question of superheated steam, the average coefficients of heat transfer are found to be 2500 to 3000 for outputs from 15,000 to 25,000 kcal per sq m per hr, while in heaters still smaller values prevail. In these heat exchangers a situation exists entirely different from that in a tube 500 mm (19.68 in.) long and 17 mm (0.669 in.) in diameter with which Jakob carried out his experiments on saturated steam, and in which he dealt with outputs of 175,000 kcal per sq m per hr with saturated and 225,000 kcal per sq m per hr with superheated steam.

In order to elucidate the processes of heat exchange the author used a cast-iron heater coil 30 m (98.4 ft) long and 0.08 m (3.14 in.) in diameter, in which the first meter (39.37 in.) stood vertically, this being done in order to make it possible to carry through the calculation under the simplest conditions prevailing on both sides of the heated wall. The saturated heating steam had a temperature of 115 C (239 F) or a pressure of 1.74 atm abs while the water boils at 100 C (212 F), thus giving a temperature difference of 15 C (27 F).

The dimensions of the heating area were 0.25 sq m per m of length, or in all 7.5 sq m (80.7 sq ft). It was assumed that the coil has been in use for a considerable time so that on both sides certain deposits of rust and incrustations have formed, so that δ/λ was accepted to be $^1/_{10,000}$. The coefficient of heat transfer of such a coil was found by experiment to be on the average 2000 kcal per sq m per hr per deg C (408 Btu per sq ft per hr per deg F). The coefficients of heat transfer on the steam side α_D and on the liquid side α_F are approximately equal and amount to 5000. The evaporating capacity of the coil is about 30,000 kcal per sq m per hr, giving a total output of 425 kg per hr (936 lb), so that the steam flows in a saturated state with a velocity of 23.6 m per sec (76.6 ft per sec). After it has been superheated 100 C (180 F), its velocity for the same output increases to 32 m per sec (105 ft per sec). With such a high velocity the thickness of the film of water in the forward part of the coil (both the thickness of the flowing film, as well as the boundary film at rest) on the same side is materially reduced and this increases α_D. One may with some certainty assume that α_D increases from 5000 to 20,000, while α_F is approximately 6000 kcal per sq m per hr per deg C (1224 Btu per sq ft per hr per deg F).

Under these conditions the coefficient of heat transfer in the first meter of the length of the coil is approximately 3150 kcal per hr per deg C difference. If saturated steam is used in the first meter of the coil, 3.28 kcal per sec are transferred.

Steam in the amount of 118 g per sec enters the coil in a state of powerful turbulence because of flow through a valve. If this steam is superheated 100 C (180 F) its heat of superheat is 5.295 kcal per kg (1 kcal per kg = 1.8 Btu per lb). It is therefore greater by 2.67 kcal per kg, or 81 per cent, than the heat which, under the conditions considered, can be transmitted through the heater wall. From this it would appear that in the first piece of the coil, one meter long, no steam can permanently condense if to start with it has been superheated 100 C. Even if at some point on the wall a particle of superheated steam is cooled from 215 C to 115 C (419 to 239 F) and condensed to water, this will be immediately reevaporated by the superheated steam flowing by it with a velocity of 20 to 30 m per sec (65 to 98 ft per sec), particularly as its heat of superheat is greater than the amount that can be transferred to the wall in the first section of the coil.

It must also be borne in mind that no condensation of superheated steam to water can take place over any section of the greater part of the initial heating surface, because, as Jakob has very clearly shown, the molecules of superheated steam impinging on the wall lose their temperature, but do not condense; they jump back and assume the average temperature of the turbulently flowing live steam. According to this concept of the process in the first meter of length of the coil, the major part of the heated surface is dry and the superheated steam acts with respect to it just like hot air, i.e., the heat transfer to these completely dry surfaces is only quite small, but still greater than that transferred from hot air. This latter phenomenon is due to the fact that the particles of live steam impinging on the heated surface give up to the latter not only a part of their heat of superheat but also the heat of evaporation, whereupon the steam particles rebound in the form of water particles, and these latter are reconverted into steam only because they take up the heat of superheat from turbulently flowing live steam.

It is because of this that the process described as affecting the first meter of length of the coil applies also to the next section of the coil, the length of which is determined by various circumstances, particularly the amount of superheat, the magnitude of the velocity of the turbulent flow, and the coefficient of heat transfer.

It would appear, therefore, that the heated surface which comes first into contact with the live steam in coils as well as evaporators, vertical or horizontal, acts as a cooling device, working with a more or less reduced heat transfer, and it is only after the superheat has been completely eliminated that normal conditions are established, such as obtain from the start when we are working with saturated steam. When, therefore, it is desired to obtain a regular output from the heated surface when using superheated steam, it is advisable to convert it into saturated steam before admitting it into the apparatus or at least into "condensing live steam." This does not require any complicated and expensive installation. All that is needed is a simple device built like a jet condenser, with a small pump to circulate a small share of the hot condensate. The output of the circulating pump is to be so selected that only a small amount of the condensate pumped in is not evaporated but returned to the steam chamber. If this precaution is taken there is no reason to fear that the performance of the heated surface will be unfavorably affected by the small amounts of water carried over into the chamber with the steam in the shape of small droplets. Naturally, in so far as the evaporation is concerned, no heat is lost, while if cold water were used, there would have been evaporation losses amounting to from 1 to 2 per cent. No share of the total heat is here lost and any loss may be only in effective heat. The author's explanation of the operation of the heating steam, in particular heat exchangers, shows, as he claims, how careful one must be in attempting to transfer experimental results obtained with laboratory apparatus to actual practise, if one wants to avoid grave errors.

It may be mentioned in this connection that heat transfer in the case of drop condensation where the major part of the heated surface is not affected by any film of water that can be discovered is much greater than in the case of film condensation which, as has been found in laboratory apparatus, occurs only where saturated steam is used as the heating medium, as this steam gives up its heat of evaporation even to such places as have been described. If live steam is used, heat transfer is materially reduced even if some drop condensation takes place. (Dr. H. Claassen, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 77, no. 42, Oct. 21, 1933, pp. 1141–1142, *et*)

VARIA

Reduction of Unemployment in Great Britain

ACCORDING to a statement issued by the Ministry of Labor, the figures for September 25, 1933, show a marked decrease in the number of unemployed persons. There were 74,410 less unemployed than in the preceding month and 521,284 less than a year ago, the present figure having brought down the number of unemployed to 2,336,727. With regard to the employment of insured persons, last month's returns show an increase of 86,000 for the month, or 792,000 more than a year ago, which bring the number of employed up to 9,943,000. It is pointed out that the figures for each month of the present year, with the exception of July, in which there was an increase of 4000, have indicated a steady decrease in the number of unemployed persons, the total being well over half a million less that at the end of January last. Among the industries which show the largest increase in employment during the January-September period is coal mining, which now has 46,000 fewer unemployed, mainly in the Midland, Yorkshire, and North-Eastern areas. The reduction of unemployment in other industries is indicated by the following figures: iron and steel, 8000; general and electrical engineering, 5000; motor-car manufacture, 6000; metal-goods manufacture, 8000; pottery, 7000; cotton, 11,700; wool, 5500; hosiery, 2000; jute, 1200; and boot and shoe, nearly 4000. These eleven important industrial groups show together a total decrease of over 104,000 unemployed. (*The Engineer*, vol. 156, no. 4057, Oct. 13, 1933, p. 347, *g*)

Patents and Government Departments

UNDER the Order in Council (Great Britain) of July, 1915, amended in 1928, the Department of Scientific and Industrial Research is permitted to take out patents for inventions and discoveries made by its servants and research workers. Recent events have brought the troubles of the Department with private inventors to a head, and an editorial in *The Engineer* attempts to present the principal aspects of the problem.

At first, the Department of Scientific and Industrial Research directed its energies purely to encouraging and helping financially research associations established by industries; but soon the Department found it necessary to undertake researches of its own in the national interest, and in addition to the National Physical Laboratory, numerous researches are directed by it. Many of the results of its work are patentable. The Department had three ways to handle this problem: (1) take out patents in the ordinary manner; (2) throw the results open to the world; or (3) reveal them to certain selected individuals or firms for the purpose of industrial development. At first sight it would appear that the right course for a public body supported by public funds, is to publish openly its discoveries and inventions. It was feared, however, that if any one who desired could use the invention, no one would have an incentive to work hard to push it. To guard against this the Department decided to keep control of the inventions by patenting them and to license the use of them under royalties which would give the further advantage of providing means to check or control foreign competition.

Against this argument in support of departmental patents, one must set down a possible injustice. It may happen that the Department is working on a problem which has also attracted the attention of private individuals or firms, and that the same solution is reached by the Department, with its excellent resources and public moneys, before the individual or firm. If, then, the Department covers the invention by a patent, the private worker is robbed of the fruits of his labor. Manifestly, the condition set up is undesirable. For, on the one hand, the private individual will be discouraged from making inventions, foreseeing that it is more economical to leave that work to the Department; or, on the other, he may be tempted to take out a great number of "keep off the grass" patents in order to circumvent the Department. There are already too many patents of this kind, and anything which tends to encourage their multiplication is to be deprecated. But in this connection it is very important to remember that while the D.S.I.R. has no right to ask private manufacturers what they are doing, the research program of the Department is open to all manufacturers. Furthermore, if any firm engaged in a research has reason to believe that the D.S.I.R. is interested in the same research, it will be shown what the Department is doing, and if the Department is satisfied that the firm is covering the ground, it may either cooperate with it or delete the item from its own program.

The third alternative open to the Department is to place its inventions in the hands of a selected firm or group of firms with permission to protect and use them, either for or without a "financial consideration." While the arguments which may be advanced against that course leap to the eye, it has merits which cannot be overlooked, and which in certain cases would seem to outweigh the objections. In any case it cannot be hastily dismissed on the ground that it may be a form of favoritism. In the cause of national economy it may be the right and proper thing for a national body to go direct to one or two firms which, in their association, are known to have the means and the ability to make the best of an invention. (*The Engineer*, vol. 156, no. 4056, Oct. 6, 1933, p. 335, *g*)

Identification of Firearms

THE author cites a number of cases of gross miscarriage of justice due to attempts made at the identification of firearms by men ignorant of the art or negligent in their work. The author deals particularly with the Stielow case, famous in the criminal annals of the State of New York. Among other things, he gives a tabulation of the more important characteristics of various guns, both revolvers and automatics, which make it possible to determine, in a general manner, from what weapon a bullet has been fired. Only rifled firearms leave clearly identifiable marks on the bullets. The nominal diameter of the gun does not, in itself, show the precise dimension across the lands, and the bullet characteristics may be also affected by the type of cartridge (pin or center fire, rim or rimless—including what is known as rimfire) and method of loading. The bullets are also different, e.g., plain lead, metal-jacketed, and soft-pointed (no steel-jacketed bullets are made in America, but are popular in Europe). Certain instruments are now available for the identification of bullets, such as the helixometer, used for the examination of the inside of firearms to determine the condition of the bore or to view particular marks. The general methods of procedure in the identification of firearms are next set forth, including certain special characteristics of bullets, e.g., peculiar scratches on bullets fired from automatics, and not encountered in other types of firearms. Each and every barrel has its own "finger prints" which it leaves on a bullet, and identification by these marks is just as certain as identification of a criminal by his finger prints. (J. S. Hatcher, Executive Office, Baltimore Ordnance District, U. S. Army, in *Army Ordnance*, vol. 14, nos. 79 and 80, July-August and September, pp. 27 to 32 and 89 to 95, illustrated, *dA*)

SYNOPSES OF A.S.M.E. PAPERS

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AERONAUTICAL ENGINEERING

I—The Problem of Elastic Stability. Increasing load on a structure brings about "failure," either in the familiar way in which the material does not stand up at some point or by the way in which a part under compression reaches a state of instability and buckling occurs. The first of these modes of failure is a failure of material; the second is of a more structural character. The paper discusses preliminary stress calculations, independence of the two types of failure, characteristics of structures influencing each type of failure, relation of the characteristics to weight saving, secondary failures, experimental and analytical methods of studying buckling problems, comparison of different methods of analysis, the simple strut, column formulas, other stability problems, and possible methods of analysis of monocoque construction. (Paper No. AER-55-19a, by L. H. Donnell.)

II—Strength of Thin Metal Structures Beyond the Stability Limit. When thin sheet metal was first used for aircraft, the design was in accordance with the usual laws of elasticity, and when buckling occurred in any part it was considered as failure. Frequently it was observed, however, that the buckling disappeared after the load was removed, without permanent deformation. This led to the study of thin sheet metal when used above the stability limit. The paper considers two methods of designing structures for thin sheet metal—one is to endeavor to make the buckling load correspond to a stress equal to the elastic limit of the material, and the other is to allow the structure to go into the buckled state at a stress below the elastic limit and then to determine the allowable load on the structure before permanent deformation would take place. It may be possible that a photoelastic study of buckled sheets would lead the way to a solution. (Paper No. AER-55-19b, by E. E. Sechler.)

III—Analysis of Some Typical Thin-Walled Structures. The structural skeleton of an airplane of the orthodox type can be considered as a truss, and the structural analysis uses, in general, the familiar methods. Also the structural analysis of the spar-rib type of wing system can be done by the theory of elastically supported continuous beams. The structural analysis of thin-walled structures is a much more complicated problem. There are different methods of attack. A survey of typical cases shows that there is a possibility of producing usable information. Experiments are being carried out on the stability and ultimate failure of cylinders in compression, bending, and torsion. (Paper No. AER-55-19c, by Th. von Kármán.)

Possibilities of Cabin-Type Autogiros. The development of the autogiro has virtually been made on the open-cockpit type, one to three place, weighing from 1000 to 3000 lb, and with an engine of 80 to 400 hp. The question has often arisen if it could be adapted to passenger transport. The author asserts that the cabin-type autogiro is entirely possible. Three cabin autogiros have been built, markedly different as to type, size, power, and general construction. The trial flights in this country suffered because of lack of mechanical starting units, not then available. Detail studies have been made of various sizes of cabin-type autogiros, and the author gives an idea of the possibilities in this development. (Paper No. AER-55-20, by A. E. Larsen.)

Principle of Similitude as Applied to Research on Thin-Sheet Structures. Any program of research on airplane structures must give consideration to the design and stress-analysis requirements of the Army, the Navy, and the Aeronautics Branch of the Department of Commerce. The requirement that the breaking strength of the structure or of its component parts must be the basis of strength calculations places a difficult problem before research men. Hooke's law of proportionality of stress to strain forms the basis of the mathematical theory of elasticity, and above the proportional limit of the material (which for aircraft metals may be taken as the elastic limit), formulas based on this law do not apply. Formulas are derived from the standpoint of the mathematical theory of elasticity which fit the data quite accurately for stresses within the elastic limit. For stresses above the elastic limit an empirical formula will be necessary. In so far as the practical use of the data is concerned, since stresses above the proportional limit are involved, a derived formula may not be as desirable as the experimental curve. The value of the experimental curve depends to a great extent upon the proper selection both of the coordinates and the parameters. (Paper No. AER-55-21, by John E. Younger.)

APPLIED MECHANICS

The New Theory of Plasticity, Strain Hardening, and Creep, and the Testing of the Inelastic Behavior of Metals. The knowledge of the inelastic behavior of metals has experienced considerable growth in the last few years. To draw all the advantages possible from the experiments, frequently very difficult, an effort has been made to bring the entire development under some dominating physical ideas. These ideas are in fact very old, and deal mainly with the proper conception of the hidden elastic energy that is responsible for the statical component of the strain hardening. The analytical treatment of the inelastic behavior gives promise of being valuable not only in the testing of materials, but even for the designer of machines used in the forming of metals. (Paper No. APM-55-18, by H. Hencky.)

Stress-Concentration Phenomena in Fatigue of Metals. This paper consists of two parts: (I) General Considerations, which is a brief review of available data on the effect of holes, fillets, grooves, etc., on endurance strength; and (II) Some Observations Concerning Fatigue Fractures, wherein notes on crack propagation as related to stress-concentration phenomena are presented. (Paper No. APM-55-19, by R. E. Peterson.)

Working Stresses for Columns and Thin-Walled Structures. In metallic structures such as airplanes, airships, ships, bridges, etc. slender bars, thin webs, and thin-walled tubular members are very often used. In choosing working stresses for such structural elements, not only the mechanical properties of the material but also the elastic stability of these elements should be considered. The method employed in choosing working stresses for such structures is well illustrated in this paper by several examples. (Paper No. APM-55-20, by S. Timoshenko.)

FUELS AND STEAM POWER

Stresses in Boiler Tubes Subjected to High Rates of Heat Absorption. In order to get a more nearly accurate picture of the stresses in thick boiler tubes subjected to high rates of heat absorption, an investigation of the subject, under the supervision of the author, was made using as nearly accurate experimental data as could be found for mild steel and employing theoretically correct relations for the stresses in thick tubes. After calculating the stresses by relations derived for a constant ratio of stress to strain, the results were corrected for plastic flow in the tube wall where the stresses exceeded the elastic limit of mild steel, and also for creep which occurs when mild steel is stressed for long times at elevated temperatures. The stresses were investigated for non-uniform heat absorption around the tube circumference as well as for a uniform rate of heat absorption.

Details of the investigation and the results which were obtained are set forth at length in the paper. (Paper No. FSP-55-6, by William L. De Baufre.)

Pulsation of Air Flow From Fans and Its Effect on Test Procedure. Error that results from velocity-pressure determinations of volume when a pulsating velocity exists is discussed theoretically. The paper also shows experimentally that such pulsation is of frequent occurrence, and gives quantitatively the amount of the error. It further suggests necessary changes in fan-testing procedure. (Paper No. FSP-55-7, by Harold F. Hagen.)

Performance of Modern Steam-Generating Units. This paper is the final report on a study made of the performance of 250 large steam boilers over a period of three years. The results of the first year's study were reported at the 1929 Annual Meeting of the A.S.M.E., and a summary of the full three-year period was presented at the 1931 Annual Meeting. The study was requested by the Central Station Power Committee of the Power Division. The primary object was to study boiler outages and their causes and the effect of such factors as severity of use, design, fuels, and methods of firing on boiler reliability, in the hope that a yardstick might be obtained by which the individual operator could measure the performance of his own units and predict the probable availability of new designs. The data obtained from each unit are presented, together with some comparisons of types and classes of unit. There also is a discussion of primary causes of boiler shutdown, which has not appeared in either of the previous papers. (Paper No. FSP-55-8, by C. F. Hirshfeld and G. U. Moran.)

Influence of Bends in Inlet Ducts on the Performance of Induced-Draft Fans. This paper shows the great loss in capacity and efficiency of a fan that results from the location of elbows or bends close to the inlet boxes. The loss is shown to be a function of the type of bend, of its "aspect ratio" or ratio of depth to width, and of the direction in which the air is turned in the bend. By the use of guide vanes in the bend the loss can be almost entirely prevented. When scroll inlet boxes provided with guide vanes are used, this loss does not occur, but the capacity with such boxes is low, although the efficiency is maintained. The cause of the loss is not the friction in the bend, but is the poor distribution of the air leaving the bend and entering the inlet box. The use of a short length of straight duct between the bend and the inlet box will reduce the loss appreciably. Measurements by pitot tube of the distribution of velocity and static pressures at the entrance to the inlet boxes will indicate the existence of this loss and the desirability of inserting guide vanes in the bends. (Paper No. FSP-55-9, by L. S. Marks, J. Lomax, and R. Ashton.)

A System for the Measurement of Steam With Flow Nozzles for Turbine Performance Tests. In this paper the authors give particulars regarding a system of steam-flow measurement by means of a nozzle for performance tests of jet-condensing, non-condensing, or extraction turbines where condensate measurements are out of the question. The system as outlined is on a laboratory basis in order to insure the accuracy necessary when steam-turbine guarantees are involved. One of the two appendixes presents an account of tests on which the system is based; the other deals with formulas for steam flow. (Paper No. FSP-55-10, by S. A. Moss and W. W. Johnson.)

Stoker Developments at The Detroit Edison Company's Delray Power House No. 3. Experience gained from nearly three years' operation of the large single-ended stokers at Delray has led to developments and improvements in design, the application of which has made them comparable with other types of coal-burning equipment. Improvements have been made with two things in mind—namely, an increase in efficiency of combustion and a reduction of maintenance by decreasing burned stoker parts. All improvements possible, particularly those to improve combustion, have not as yet been completed; however, changes that have been incorporated have materially improved performance. Automatic control of preheated air to the various parts of the fuel bed has been sufficiently developed to establish it as a desirable and valuable aid to combustion, particularly with long stokers burning high-volatile coal. One of the stokers has been operated successfully for a short period with preheated-air temperatures as high as 500 F. Development of a similar air-control system, manually operated, under two boilers in the Beacon Street Heating Plant, handling cold air, has resulted in an increased steaming capacity of 31 per cent and an increase in calculated boiler efficiency of from $\frac{1}{2}$ to 2 per cent. The paper is a description of the Delray installation, but reference is made to the large double-ended stokers, supplied with cold air, and the manually operated metered air control in the Beacon Street Heating Plant. (Paper No. FSP-55-11, by Paul W. Thompson and Fred J. Chatel.)

IRON AND STEEL

Progress in Iron and Steel. Pig-iron production rate was unprecedentedly low—the lowest since 1898. Steel operation was at record low percentages as compared with potential capacities. The report covers blast furnaces, Lake Superior iron ore, coke ovens, open-hearth plants, rolling mills, electric-weld pressure pipe, and refractories. The trend continues toward greater centralization of steam and power production in units of larger size and greater efficiency, toward higher steam pressures and more efficient heat cycles, and toward more careful control of combustion. (Paper No. IS-55-1.)

The Morgoil Roll-Neck Bearing. For several years a need has existed in two-high hot rolling mills for a rugged, precision-type bearing having a capacity great enough to carry existing loads, and which could be installed in the limited space available, without reduction of neck strength. This paper reviews the experimental work with roller bearings which eventually led to the development of a unit-type oil-lubricated sleeve bearing. A brief review of pertinent laws of bearing design is included, together with their application to rolling-mill problems. Following a description of the Morgoil bearing, some results of field tests are included which show how successfully the bearing has met the conditions imposed upon it. (Paper No. IS-55-2, by F. P. Dahlstrom.)

Recent Developments in Merchant-Bar Mills. After first discussing trade demands on merchant-mill products, the author points out the value of research and records in the making and rolling of steel. He then proceeds to discuss the factors affecting the quality of product in the merchant mill, and the items to be considered when selecting the type of merchant mill for a given range of products in a given plant. He next takes up the use and arrangement of vertical mills and the application of roller bearings to mill rolls, in case of existing and new mills, discussing also the economic and practical considerations involved. He then gives particulars of a new transfer-table design, and points out the uses and advantages of electric-driven flying shears. Finally, cooling-bed requirements to meet the needs of various merchant-mill products are then considered, as well as cooling-bed design and operation, objections to the double cooling bed, and double cold shearing from a single bed. (Paper No. IS-55-3, by G. L. Fisk.)

Carburizing With Butane Gas. The hydrocarbon gases of the paraffin series which are being used for commercial carburizing include methane (natural gas), propane, and butane. These hydrocarbons used without the admixture of air or other gases apparently give up carbon to the steel during certain cracking processes which occur at certain rather sharply defined temperatures and other conditions. Operating conditions which give satisfactory results with one hydrocarbon may not produce satisfactory results with other hydrocarbons. These conditions are not difficult to meet when fully understood.

Well-controlled butane offers: (1) Smaller temperature range than commercial solid carburizers; (2) carburizing material at low cost; (3) maximum carburizing rate at temperatures metallurgically and economically advantageous; (4) chemically constant carburizing material; (5) carburizing material requiring no complications, such as admixture of air or other gases; (6) no labor or space within the plant is required for handling or storage of solid carburizer; (7) carburizing process so free from dust and dirt that with proper furnace equipment it may be placed in the regular factory line of manufacture; (8) absolute control of depth and character of case.

The paper gives some details of the author's experiments, certain general observations regarding the physical chemistry and a table of physical constants of the paraffin hydrocarbons, a description of flowmeter for measuring the flow of carburizing gas to the furnace. (Paper No. IS-55-4, by C. W. Spicer.)

European Supplement to Progress Report of the Iron and Steel Division, 1931. European steel works were visited by the author, and outstanding developments and innovations are recorded. A large tube mill in Germany has adopted a phenol-formaldehyde condensation product for rustproofing pipes. A process for extruding seamless tubes has been perfected. A steel works has improved the process for rolling seamless drums up to 22 ft in length and 44 in. in diameter. Of interest is the automatic welding of wide-flanged beams. There is an improved multi-pass continuous mill. Discussion of the report carries further information. (Paper No. IS-55-5, by W. Trinks.)

Effect of Reradiation on Heat Transmission in Furnaces and Through Openings. In heat transmission by radiation, the reradiation of heat from adjacent surfaces has been a perplexing question. Radiation of heat through openings in furnace walls, radiation in electric furnaces having heating elements under the roof

only, and radiation in some types of oil stills from muffles on the floor to the tubes under the roof are all cases in point. In this paper accurate methods of calculation are developed, and curves are presented from which the reradiation and total radiation factors can be read at a glance, for various shapes and proportions of radiating surfaces or openings. Incidental to the chief results, two methods of solving integral equations are presented. The theoretically developed values are checked and substantiated by actual test measurements. (Paper No. IS-55-6, by H. C. Hottel and J. D. Keller.)

The Rolling and Extrusion of Aluminum and Its Alloys. This paper outlines the history of the development of the manufacture of aluminum sheet, wire, and rod. It then discusses the growth of the demand for aluminum alloys and the problems that research laboratories and engineers had to solve before the manufacture of these alloys became practicable. A description is given of mills for rolling standard structural shapes, with reports on tests made to ascertain the power required to roll strong alloys. The extrusion of aluminum alloys is discussed, touching on the reasons for using extrusion in place of rolling, and explaining the limitations of the extrusion method of manufacturing shapes. (Paper No. IS-55-7, by Robert L. Streeter.)

Strength of Roll Necks. (Report of the Special Research Committee on Heavy-Duty Anti-Friction Bearings.) The increasing use of anti-friction bearings for roll necks, which frequently necessitates a change in the customary proportions of roll body and roll neck, has made the question of roll-neck strength an important one. At the juncture between roll neck and roll body, stresses of high intensity occur which cannot be evaluated by the familiar formula of mechanics, and regarding which few directly applicable data were available. In order to evaluate the concentration of stress at this point, and to indicate the manner in which the stress concentration is affected by varying proportions of roll body and roll neck, rupture tests were made with model rolls of gypsum plaster, having various proportions and several different sizes and shapes of fillet. The test conditions were made to correspond as closely as possible to those of actual rolls in operation. The experimental results are shown, and are compared with previous data. The effect of stress concentration in rolls made of various materials is also considered. (Paper No. RP-55-5, W. Trinks and J. H. Hitchcock.)

MACHINE SHOP PRACTICE

Progress in Machine-Shop Practice. The engineers responsible for design and fabrication have brought out some phenomenally productive machine tools and improvements in manufacturing technique which will tend to render obsolete the tools and methods that earned adequate profits in past years. The report covers welded structures, die casting, forging machinery, improved machine tools, material-handling facilities, lathes, precision grinding machines, screw machines, drilling and milling machines, die-cutting and engraving and gear-generating machinery, hobbed integral keys, cemented carbide tools, and developments in drop-forging hammers. (Paper No. MSP-55-1.)

OIL AND GAS POWER

Progress in Oil and Gas Power. This report, contributed by the A.S.M.E. Oil and Gas Power Division, was prepared by Dr. P. H. Schweitzer. Investigation in the modern high-speed oil-engine field is turning to fuels and their ignitibility. Projected research is destined to find the best ways to determine the ignitibility of an oil and to express it in comparable units. An important factor in retarding the development of the large marine Diesel engine here is the fuel-price situation. Active development of methods for utilizing boiler fuel for Diesel engines is now in progress. The report covers stationary engines, marine oil engines, automotive Diesel engines, aircraft oil engines, locomotive engines, research, the work of the National Advisory Committee for Aeronautics and the Pennsylvania State College, gas engines, and the business outlook. (OGP-55-2.)

Improving Operation and Overall Economy of Diesel-Engine-Driven Generating Stations. The majority of Diesel plants are operating far below par, and if real economical operation is to be obtained, better supervision is necessary. The larger plants can afford to retain engineers capable of producing results. Small plants could engage supervising engineering companies on a percentage of the net savings. If boiler fuel oil could be proved to operate more economically, it should be used. (Paper No. OGP-55-3, by H. W. Stalnaker.)

Metallurgical Problems of the Diesel Engine. The metallurgical problems of the Diesel engine consist more in selecting the most suitable material for a given application than in trying to find the solution for a chronic condition. Most of the problems encountered in operation are ones of design, but for economical reasons they often become metallurgical. It is believed that a more careful study of the details of design, with a view to eliminating localized overstress and providing better lubrication, will end most of the troubles. Where such consideration is given, the performance of the Diesel engine is most reliable, and many engines are building up records which rival those of the older reciprocating types of steam engines. (Paper No. OGP-55-4, by R. J. Allen.)

Inertia Supercharging of Engine Cylinders. A theory is developed for the supercharging effect produced in an engine cylinder when a long suction pipe is attached. As a preliminary to this theory equations are given for suction and exhaust flow where no inertia effects are present. Results of the theory are compared with experiment, and some data are given on engine performance when supercharged in this manner. (Paper No. OGP-55-5, by E. S. Dennison.)

Some Phases of Light-Weight Diesel-Engine Design. The paper analyzes the economics of light-weight Diesel-engine design. This is justified if these points are satisfied: Lower cost per unit (cost per horsepower), lower cost of operation for the unit, reduction in time of work accomplished, and reduction in engine size. The proper coordination of three principles will produce an engine very much under conventional weights, these being increased mean effective pressure, increased piston speeds, and intelligent use of material having a high ratio of strength to specific gravity. (Paper No. OGP-55-6, by P. B. Jackson.)

Spray Characteristics of a Jerk-Pump Fuel-Injection System. Tests were conducted with special spray-research apparatus in the Oil Spray Laboratory at Pennsylvania State College, aided by the loan of jerk-pump injection equipment. The application of the conclusions reached is summarized as follows: Variables that could be changed in engine installation are speed, load, and nozzle-opening pressure. These would affect the combustion line on the indicator card only as they changed temperature, turbulence, and spray characteristics. Within the range tested of these operating variables, only opening pressure would change spray characteristics enough to produce a notable effect on the combustion. It would also limit the minimum load that the engine could carry. The effects of speed and load on the spray would be negligible compared to their effects on temperature and turbulence. Combustion would be practically free from the effects of changing spray characteristics with a constant nozzle-opening pressure. (Paper No. OGP-55-7, by O. F. Zahn, Jr.)

PETROLEUM

Fluid Friction at Parallel and Right Angles to Tubes and Tube Bundles. There has long been felt a need for formulas or curves suitable for predicting pressure drop of fluids flowing at right angles to tubes as well as inside of tubes and parallel to them. As in the condition of flow inside of a tube, the variables affecting pressure drop are velocity, viscosity, density, size, and geometric arrangement of tubes and length. Systematic tests were run on commercial heat exchangers, but it was found necessary to build a special heat exchanger to obtain a more general formula. This exchanger was arranged for heating with steam and cooling with water on the inside of the tubes, and the tubes were arranged multi-pass for cooling and single-pass for heating. A formula is recommended for correlating friction data for fluids flowing outside of tube bundles. It was determined that the effect of heat transfer on fluid friction is negligible in the region of turbulent flow. Different curves for friction factor should be used for heating and cooling in the region of streamline flow. Data on fluid flow cannot be successfully correlated using the so-called film temperatures for determining fluid properties. The recommended formula can be used to include the resistance to flow of gases. The use of the "equivalent diameter" to take care of various tube diameters and tube spacing is recommended only where the tube rows are staggered and where the tube spacing does not exceed twice the diameter of the tube. (Paper by E. N. Sieder and N. A. Scott, Jr.)

RESEARCH

Performance of Cutting Fluids in Drilling Various Metals. This is Progress Report No. 4 of the Sub-committee on Cutting Fluids of the A.S.M.E. Special Research Committee on the Cutting of Metals. It gives the results of a series of drilling tests on nine different metals using eleven different cutting fluids. Modern twist drills having 30-deg helices, ranging from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. in diameter, were used.

The materials consisted of a cast aluminum alloy, free-cutting brass, cast iron, malleable cast iron, S.A.E. 1020 steel, S.A.E. 1035 steel, carbon tool steel, S.A.E. 3150 steel, and S.A.E. 1112 steel. The eleven cutting fluids consisted of dry cutting, borax water, two soluble oils, lard oil, two straight mineral oils, two compounded oils, and two sulphurized oils.

For each material a formula for torque and thrust was developed as a function of variable diameter and variable feed. Constants for these formulas for dry cutting and each of the eleven cutting fluids are determined. The influence of the different cutting fluids on each metal is shown. With the net output power for drilling dry expressed as 100 per cent, the savings made are as follows:

- 33.3 per cent for S.A.E. 1020 steel when using a sulphurized oil
- 31.7 per cent for aluminum alloy when using a 90 per cent mineral–10 per cent lard oil
- 26.0 per cent for S.A.E. 1035 steel when using a sulphurized lard-mineral oil
- 23.0 per cent for S.A.E. 3150 steel when using a sulphurized mineral oil
- 21.0 per cent for carbon tool steel when using sulphurized mineral oil
- 17.2 per cent for cast iron when using a mineral oil containing 5 per cent oleic acid
- 10.5 per cent for malleable cast iron when using any kind of an oil, such as lard, mineral, compounded, or sulphurized
- 6.8 per cent for S.A.E. 1112 steel when using a sulphurized lard-mineral oil

No appreciable difference is made whether free-cutting brass is cut dry or with any kind of a cutting fluid.

In the development of the formulas for torque and thrust, it was found that the same results of the exponents for drill diameter and feed would be obtained regardless of the diameter of the drill used in the variable feed tests and regardless of the feed used in the variable drill diameter tests. The values of these exponents are not influenced by the type of cutting fluid used. The torque and thrust lines as a function of feed or diameter as the variable are merely displaced vertically, if affected at all. The constants of the torque and thrust formulas, however, indicate the cutting characteristics of the cutting fluids.

The torque and thrust formulas for all kinds of steels as covered in the paper are found to be identical except for different values of the constant. Other metals, however, produce formulas apparently characteristic of that metal. In other words, different formulas as summarized in Table 4 are developed for the aluminum alloy, the free-cutting brass, cast iron, malleable iron, and steel. (Paper No. RP-55-1, by O. W. Boston and C. J. Oxford.)

Grinding Cemented Tungsten- and Tantalum-Carbide-Tipped Tools Economically. Present-day speeds and efficiency in handling enormous production have been made possible only by the development of modern tool equipment and set-ups which hasten service and assure quality. In this paper the author outlines a tungsten-carbide-grinding set-up which is efficient and profitable. (Paper No. RP-55-2, by J. M. Highducheck.)

A Test Method for Determining the Quantitative Effect of Tube Fouling on Condenser Performance. The purpose of this paper is to show the importance and practicability of adding another vital measurement to condenser tests which will give a specific value for the degree of tube fouling existing at the time of the test. Since the majority of condenser installations are subjected to some type of fouling, and since conventional means of cleaning seldom if ever restore the tubes to their original state, it is evident that the performance of many condensers cannot be correctly appraised without a knowledge of their cleanliness factors. Cleanliness factor is the term used to express the degree of tube fouling, and is defined as the ratio of the heat transmittances of fouled and new tubes subjected to the same operating conditions. Several methods of measuring the cleanliness factor are described, and data from six tests are included. The importance of avoiding inconsistent procedures in making the measurements and computing the data is stressed. (Paper No. RP-55-3, by P. H. Hardie and W. S. Cooper.)

The Pressure of Saturated Water Vapor in the Range 100 C to 374 C. The method and apparatus employed, and the measurements made in this determination of the vapor pressure of water are described, and the results obtained are given and formulated.

The method used was the "static method" in which the pressure is determined at the stationary boundary between the liquid and vapor phase in equilibrium at a constant temperature in a closed container.

The container for the water sample was a calorimeter specially built for high-pressure work. Pressures were measured by a precision piston gage which balances the pressure by the gravitational force on a piston loaded with weights. Temperatures were measured by platinum-resistance thermometers supplemented by thermoelements.

A total of 394 measurements were made at 38 temperatures distributed to facilitate formulation of the pressure-temperature relation.

The formulation was made by using an empirical equation which was fitted to the results in two temperature ranges. Values of pressure and its derivative with respect to temperature are tabulated from this formulation in standard atmospheres, centibars, and kilograms per square centimeter at each degree centigrade, and in pounds per square inch at each degree fahrenheit. This provides a mutually consistent group of vapor-pressure tables in convenient form for practical working tables of fundamental steam data.

It is estimated that the results are reliable to 3 parts in 10,000. (Paper No. RP-55-4, by N. S. Osborne, H. F. Stimson, E. F. Fiock, and D. C. Ginnings.)

Strength of Roll Necks. This is a report of the A.S.M.E. Special Research Committee on Heavy-Duty Anti-Friction Bearings. The increasing use of anti-friction bearings for roll necks, which frequently necessitates a change in the customary proportions of roll body and roll neck, has made the question of roll-neck strength an important one. At the juncture between roll neck and roll body, stresses of high intensity occur which cannot be evaluated by the familiar formula of mechanics, and regarding which few directly applicable data were available. In order to evaluate the concentration of stress at this point, and to indicate the manner in which the stress concentration is affected by varying proportions of roll body, and roll neck, rupture tests were made with model rolls of gypsum plaster, having various proportions and several different sizes and shapes of fillet. The test conditions were made to correspond as closely as possible to those of actual rolls in operation. The experimental results are shown, and are compared with previous data. The effect of stress concentration in rolls made of various materials is also considered. (Paper No. RP-55-5, by W. Trinks and J. H. Hitchcock.)

An Analysis of Crushing and Pulverizing Processes. Different types of crushing and pulverizing mills are mentioned to show the diversity in operating characteristics. It is clear that different types of mills have been commercially adapted to similar products, and only rarely is one type of mill used to the exclusion of all others. The principles laid down illustrate the importance of grindability. A consideration of energy requirements shows that there is a large wastage of power over that needed to produce reduction in size. The earlier work of the author is confirmed on the difference in fineness-distribution curves produced under different grinding conditions and by different types of mills. Proper choice of mill, proper loading, and the application of separators offer the opportunity to produce material of specific size characteristics or to produce material below a given size at a minimum of cost. (Paper No. RP-55-6, by Lincoln T. Work.)

High-Pressure Steam-Generator Research. This is a progress report by the A.S.M.E. Special Research Committee on Critical-Pressure Steam Boilers of the investigations with the high-pressure steam generator at Purdue University which have been carried on since January 1, 1932, and are mainly concerned with the measurement of the enthalpy of steam by the use of a condensing calorimeter designed for pressures up to 3500 lb per sq in. The heat leak was determined by assuming that the Keenan Tables were correct within the range at which the calorimeter was calibrated. Thirty-nine tests were carried on at pressures varying from 1900 to 3500 lb per sq in. and temperatures of 709 to 780 F. The results were compared with those of Keenan, Knoblauch, Callendar, and the International Tables. The Purdue University figures are in close agreement with those of Keenan, Knoblauch, and the International Tables, but show considerable variance from Callendar's results. (Paper No. RP-55-7, by H. L. Solberg, G. A. Hawkins, and P. A. Willis.)

WOOD INDUSTRIES

Progress in Wood Industries. The report covers the departments of the wood industries, such as wood-utilization research, lumber manufacturing, fireproofed wood, dry kilns, furniture making, millwork and doors, plywood and glues, woodworking machinery in general, abrasives, duct collecting, the training of engineers for the industry, investigation of mechanical properties of certain tropical timbers, and wood finishes. (Paper No. WDI-55-1.)

Modern Door Construction—Manufacture and Use. Doors, along with windows, constitute the moving parts of a building, and their manufacture must provide for all contingencies that might affect their fit and wear and durability. The many kinds of doors are de-

scribed, and the author details the methods of construction and the machines that are used. Advice is given for the proper handling of the door from the preparation of the lumber for the mill processes, through all the details of construction and finishing, the shipping of the completed product, and its installation in the building for which it is intended. (Paper No. WDI-55-2, by Sern Madsen.)

Laminating With Phenolic Resins. Phenolic resins as wood adhesives have qualities that have been long known, but commercial application has been retarded because of the cost. The method of manufacturing plywood is said to be revolutionary in the manner of applying the adhesive. The paper describes four ways in which these resins may be applied as an adhesive between two or more plies of wood or other material, these being as a varnish, as a film, as a dry powder, and as a colloidal solution. The author concludes that, despite objections raised against the high temperatures employed in laminating with resins, they constitute an ideal adhesive for thin panels. (Paper No. WDI-55-3, by Ericsson H. Merritt.)

Fundamentals of Knife-Cutting Veneers. In the last 25 years the per capita consumption of veneer in the United States has increased nearly 500 per cent. The manufacturers of veneer and its subproduct, plywood, are constantly finding new uses, better processes, and improved equipment. The principal methods of veneer cutting are undergoing marked changes and developments, requiring a clear understanding of the fundamental principles. (Paper No. WDI-55-4, by John N. and John R. Roberts.)

The Electric Molder and Its Efficiency. The great variety of molder work, involving different methods of operation and various types of cutter-head equipment to meet requirements in all branches of the woodworking industry, accounting for a wide range of expectations regarding molder performances, has caused the development of diversified points of view for appraising molder efficiency. This paper attempts to analyze basic molder design requirements, as determined by fundamental molder functions and principles of molder cutting actions, with the hope of developing a more general understanding of reasons and requirements for electric molder efficiency. (Paper No. WDI-55-5, by Anton Vonnegut.)

Different Methods of Taking Lumber Out of Wind. Boards are generally sawed out of the green log, and although as they come off the saw carriage they are quite straight, the saw has cut some fibers crosswise, others longitudinally, or across the grain in knot formations. The strains and stresses under which the cells adjacent to the saw were confined are now released, and the exposed surfaces of the board absorb moisture or lose it, this producing warp or wind in the lumber. In the drying of this lumber the fibrous cells often become rearranged, warping it out of shape. This condition is not objectionable for certain building applications such as baseboards and trim, where the stock is nailed in place, but when making furniture, musical cabinets, case goods, etc., it is important that the permanency of the joints be assured. For this reason machinery has been devised to overcome the warp or wind in boards to be used in these ways. The paper describes these mechanical processes. (Paper No. WDI-55-6, by Armen S. Kurkjian.)

Moisture Content, Specific Gravity, and Air Space in Wood. An exposition of the physics of wood is given in the paper. It describes the cell structure of wood and the physical changes that take place as it is dried to oven-dry condition or impregnated to maximum absorption. Formulas and graphs give the relation that exists between percentage of moisture content, specific gravity, water content, total weight, and percentage of air space. The data are of interest to those engaged in wood research or wood physics or in kiln drying, wood preserving, or fireproofing. (Paper No. WDI-55-7, by J. D. MacLean.)

Modern Developments in Wood-Finishing Materials. Wood-finishing materials as used today are classified according to composition, color, drying time, use, or other properties. The paper details the development work that has produced the modern finishes, and covers the purpose that they are designed to serve and the materials upon which they are used. The many stains, wood fillers, coaters and sealers, lacquers, and varnishes are described, their constituents are revealed, and their method of application is fully covered. (Paper No. WDI-55-8, by M. J. Pearce.)

Accelerated Varnish Drying. Varnish drying on wood at a temperature of 150 F, instead of the usual lower limit of 100 to 110 F, has been attained after experimentation and tests by the authors. This finish process retains the desirable factors of appearance, durability, economy, and speed. Varnish finishes at elevated temperatures are shown by tests to be superior to ordinary finishes in durability and resistance to marring. Samples made by this system have undergone accelerated weathering for several months without failure, indicating that those finishes that take advantage of the toughness and hardness resulting from the heat treatment of synthetic and some natural resins are superior to the ordinary run of long-oil varnish finishes. A feature of the system is that it makes feasible the conveyorization of varnish finishes as well as lacquer finishes. (Paper No. WDI-55-9, by R. H. McCarthy and L. A. Lefcort.)

SPEED! TWENTIETH CENTURY, LTD., AND AN AMPHIBION CLIPPER SHIP

Galloway, N. Y.

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Has the Machine Designer Neglected Motion Study?

TO THE EDITOR:

It is certainly true, as Mr. Mogensen[1] points out, that many machine designers are not familiar with motion study and some of their work seems to have been executed without much thought as to how the operator is to fit into the picture. It is also true that foremen, supervisors, time-study observers, methods engineers, and, in many factories, the entire organization, are not familiar with motion study or the great advantages that may result from the application of this technique. Perhaps one group cannot be accused of neglecting motion study more than another—industry as a whole seems to have overlooked this valuable tool until recently. Now with some companies adopting it whole-heartedly and training all of the members of their organization in the technique of micromotion study, it seems evident that competing concerns will necessarily have to fall in line.

The engineer has always considered it an important part of his job to find better ways of doing things—through improved design, new materials, and from better coordination of known facts, etc. Since motion study has for its purpose finding the easiest and shortest way of doing a task from the point of view of the worker, it is apparent that this is an engineer's job and one that is in line with the kind of work that he is accustomed to do.

Many of us in the teaching profession are interested in this subject from a somewhat different angle. There are two important ways in which engineering colleges can promote the general industrial welfare through motion study. First, it is desirable that the principles underlying this subject be presented to students who eventually expect to go into industrial work of some kind. A number of colleges and universities in this country are now giving instruction in time and motion study and closely related subjects and this number increases each year. There has been rapid development in the method of presenting this subject and today many schools have both competent instructors and adequate equipment to do a good job.

A second important contribution that the colleges and universities may make to industrial progress is special research in this field. It is a well-known fact that we do not know how to work effectively—we do not know the capacities of the human body. Only through study and research will we be able to add to our fund of knowledge on this subject. When the worker uses tools and mechanical equipment he is not at liberty to work as he wishes even if he himself knows how to work effectively. The worker must operate the machine or use the tool in the way that it was designed to be used and this very often hinders efficient and easy movements.

It seems that engineers, as well as physiologists and psychologists cooperating with industry, have a real opportunity before them. Machines and tools of all kinds have been made more efficient year after year and there is no reason why, with the same concentrated study, we might not learn how to make the worker's efforts more effective. Already advances have been made. We now have a body of principles or rules of good practise which are of great value to industry but we need to add to this. Here lies an opportunity for all of us.

RALPH M. BARNES.[2]

Iowa City, Iowa.

TO THE EDITOR:

"Are we placing the emphasis in machine design properly?" That is, are we not carrying to extremes our desire to create special-purpose machinery, and, by a lack of appreciation of the possibilities of scientific job analysis, overlooking large potential economies on general-purpose equipment?

We have seen the wide-spread use of mechanical contrivances of the "never touched by human hands" variety. Automatic drills, punch presses, boxing, wrapping, soldering and buffing machines have been brought into existence because it was assumed that the human being could not produce fast enough.

We admire the engineers responsible for the design of complex machinery with labor-saving characteristics; but, as we view this apparatus in operation, we are impressed not so much with the speed as with the rhythm, the clock-like coordination of the moving parts. We sense the degree of careful planning which the engineers have incorporated into their design.

The designer has by no means overlooked motion economy. He has, however, turned his attention too strongly in one direction. Compare the operation of an automatic machine with the method that it has supplanted.

The subdivisions of the job performed by automatic and hand-operated machines are essentially identical in that each performs three major elements: "make ready," "do," and "put away." When the "make ready" and "put away" elements of a job are done mechanically, we have an automatic machine; when done manually, we have the human element in combination with a device or machine tool. But, while in the mechanical method they are performed simply and smoothly, in the old method they are complex, uncoordinated, and excessively long. Here is a lack of scientific planning and an inadequacy of equipment at the operator's disposal, necessitat-

[1] See MECHANICAL ENGINEERING, December, 1933, pp. 727–731 and 774.

[2] Associate Professor of Industrial Engineering, College of Engineering, University of Iowa. Mem. A.S.M.E.

ing wasteful and ineffective motions. Automatic machine designers have applied motion economy to cam action and mechanical fingers, but they have frequently ignored mentally directed energy and human fingers.

This unwise attitude is seriously handicapping labor. Compare, now, the construction of special-purpose machines with manually operated general-purpose equipment. The automatic machine has been planned and built to perform effectively the most elementary movements; yet how seldom is general-purpose equipment designed to capitalize the normal motions of an operator's hands and feet, and how rarely has an operator been given the advantages of proper instruction in the new method.

Operation of the automatic machine is standardized by its design, yet the manual worker is, in most cases, allowed to choose his own method of accomplishment. With several operators, it is not surprising to find the job cycle performed in a variety of ways.

Cam actions operate mechanical devices with precision, regularity, and coordination, yet conditions for a machine-tool operator are often such that balanced and rhythmic motion is impossible. He must expend unreasonable effort in order to do his job.

In highly automatic installations, materials are brought mechanically to the machine; holding devices are charged from hoppers or magazine feeds and discharged by ejectors and gravity chutes. When the same operations are performed less automatically, the workman may be required to reach at arm's length or farther for parts from high-sided tote boxes, to consume time in operating a poorly designed jig, or to lay the finished part on a pile which clutters up his workplace.

The automatic machine is periodically cleaned, greased, oiled, and otherwise pampered to insure its smooth running; the unfortunate hand operative may work under trying conditions, often seated on a backless stool of unsuitable height, with workplace poorly illuminated, his physical endurance overtaxed by his job.

The protest is often raised that modern factory workers are treated more like machines than human beings—the truth is that handwork is rarely given the scientific thought expended upon similar operations to be performed mechanically.

During the interim between the post-war period and the present depression, a tide of mechanization has swept the country. Manufacturers have hastened to make use of automatic equipment which would increase production manyfold. They have leaped from highly inefficient methods of hand operation to a mechanical idealism which the times have failed to justify. It is in the hitherto unexploited area between crude hand operation and highly automatic production that motion study has its greatest future promise. Where succeeding transitionary stages offer opportunity for economies, a cost-versus-savings analysis would enable a manufacturer to determine at what point to draw the line of additional expenditure.

Though the most efficient cycle of hand motions employed on the most effective machine tool may not show the theoretical economies of automatic equipment, such methods have virtues of flexibility and low obsolescence which often more than counterbalance. Radical improvements in basic processes are being introduced very rapidly; product design, based on public fancy, is apt to change on short notice. These factors have curbed the use of the unadaptable automatic machine.

One further question: "Will not industry soon turn from the special-purpose machine to a special-purpose unit consisting of a battery of general-purpose machines set up for serialized manufacture and operated by workmen employing motion economy methods?" This arrangement would combine reduction of overhead expense and the better utilization of labor and machinery with the greater flexibility and adaptability of general-purpose machines.

Mr. Mogensen has cited examples which show the trend already to be in this direction. Should the movement become widespread, it would open a new sales area for the general-purpose machine tool. But it will demand better design than is now generally available. Machines will have to be flexible with regard to floor location, easily adjustable, and less demanding of manual motion and energy. Here is a challenge to the machine-tool designer which, if accepted, may mean the renaissance of the general-purpose machine.

HERBERT T. SMITH.[3]

Cambridge, Mass.

Stresses in an Elliptic Ring

TO THE EDITOR:

There is an integral in the paper,[4] "Analysis of Stresses in an Elliptic Ring," by Merit P. White, which the author considers to be non-integrable, and he accordingly expands it in a series and integrates term by term. An explanation of a simple direct method of integration may therefore be of interest —one requiring only the selection of two formulas from a table of integrals and the choice of two values from another numerical table. All this, with a little algebra and arithmetic, takes only a few minutes of time, but there will still remain other cases where, as the author states, his graphical method will be superior.

The real interest in the method arises not so much in its application to the present problem as in its wider use for a class of integrals of certain square roots which, although they frequently occur in engineering problems, are not evident in Pierce's "Short Table of Integrals," or in other standard books on calculus. The present writer has had to use these integrals twice in the past year, once in a problem of the shape of steel plate in the equations of the hydrostatic chord, and again in finding the length of a hyperbolic arc. True, the path leads just inside the boundaries of the subject of elliptic functions, but even a slight acquaintance with the matter will open a new field where this knowledge will be of real practical use. It is necessary only to admit that one may use a table of logarithms without being able to compute it, or that one may take the result of an integration from a table without being able readily to derive it.

The subject is approached thus timidly in order to attract the many who could use it occasionally. Let not the skilled mathematician dismiss these elements as mere standard and routine practise unless he can point to a place where they really have been made available to those of moderate mathematical skill.

One of the characteristics of integrability in elliptic functions is the presence of terms in

$$\sqrt{(1 - k^2 \sin^2\phi)} = \sqrt{(1 - \sin^2\theta \sin^2\phi)}$$

where $k = \sin\theta \leqq 1$. The symbol k is always used in calculation, but numerical tables are in terms of angular degrees of θ. That is, the expression $E(k, \phi) \equiv E(\theta, \phi)$ when getting numerical values. Of course the θ here is not the same as the θ in the paper, but it is a standard notation.

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[3] Member of staff of the Department of Business and Engineering Administration, Massachusetts Institute of Technology.

[4] Trans. A.S.M.E., vol. 55 (1933), paper no. APM-55-5.

In the integral of the paper

$$\int_0^r \left(M_A - \frac{K}{2}x^2\right)\sqrt{\left(\frac{r^2+x^2}{r^2-x^2}\right)}dx = 0$$

the above-mentioned requirement can be introduced by substituting $x = r\cos\phi$ and $dx = -r\sin\phi\, d\phi$. The corresponding new limits of integration are $\pi/2$ and 0. Hence

$$-M_A r\int_{\frac{\pi}{2}}^{0}\sqrt{(1+\cos^2\phi)}d\phi + \frac{K}{2}r^3\int_{\frac{\pi}{2}}^{0}(\cos^2\phi)\sqrt{(1+\cos^2\phi)}d\phi = 0$$

Now interchange the limits of integration and hence change the signs of the integrals: put $\cos^2\phi = 1 - \sin^2\phi$ and put $1/2 = k^2$ under the square-root signs. We then get

$$M_A r\sqrt{2}\int_0^{\frac{\pi}{2}}\sqrt{(1-k^2\sin^2\phi)}d\phi - \frac{K}{\sqrt{2}}r^3\int_0^{\frac{\pi}{2}}(\cos^2\phi)\sqrt{(1-k^2\sin^2\phi)}d\phi = 0$$

From Hancock, quoting Legendre, the values of these integrals may be taken directly from a table, and omitting the values of zero at the lower limits we get

$$M_A r\sqrt{2}\,E(45°, 90°) - \frac{K}{\sqrt{2}}r^3\left[E(45°, 90°) - \frac{1}{3}F(45°, 90°)\right] = 0$$

since $k = 1/\sqrt{2} = \sin 45°$. From numerical tables we find $E(45°, 90°) = 1.35064$ and $F(45°, 90°) = 1.85407$, which gives $M_A = 0.27122Kr^2$.

This may be compared with Mr. White's analytical result by substituting, as given earlier in the paper, $K = M\sqrt{2}/\pi r^2$ and $M_A = 0.1221M$, which confirms his result within two units in the fourth place of decimals.

Brief accounts, such as that of Mr. White, of the solution of specific problems in elastic design are always welcome, because they may be very helpful when some unusual case arises elsewhere. And if explanation of the belated appearance of this letter seems necessary, it might be mentioned that the paper to which it refers came to the attention of the present writer only this week.

J. B. MACPHAIL.[5]

Montreal, P. Q., Canada.

Heat Effects in Lubricating Films

TO THE EDITOR:

Mr. Kingsbury's interesting paper[6] brings to mind a somewhat earlier but unpublished paper by Donald Bratt of the Brooklyn Edison Company on "Molecular Behavior in Lubricating Oil." Mr. Bratt's paper contained an analytical section in which were discussed the theoretical conclusions which may be drawn from the three fundamental equations and an experimental section in which was reported what his colleagues thought was a very elaborate experimental check on the theory. Perhaps one or the other part of Bratt's paper was ahead of its time, since the publication committee was "unconvinced" at the time. Mr. Hersey, of the Special Research Committee on Lubrication to which Bratt's paper was submitted in 1927, has asked for some appropriate mention of Bratt's work and particularly for a presentation of the analytical integration of the film-temperature equation.

Mr. Bratt's viscosity measurements on the oils he used indicated that the viscosity-temperature function could be represented as a simple exponential. If μ_{20} is the viscosity at 20 C and C is a constant, experimentally determined for each oil, then we have:

$$\mu = f(\theta) = \mu_{20}e^{-C(\theta-20)} \quad \ldots\ldots [1]$$

Equations [2] and [3] are from Mr. Kingsbury's paper without change:

$$s = \mu\frac{du}{dy} \quad \ldots\ldots [2]$$

$$s(u - u_0) = -k\frac{d\theta}{dy} \quad \ldots\ldots [3]$$

Differentiating Equation [3], neglecting for the moment the small variation of k with temperature and hence with y, we obtain:

$$s\frac{du}{dy} = -k\frac{d^2\theta}{dy^2}$$

Eliminating du/dy by means of [2], this becomes:

$$\frac{d^2\theta}{dy^2} = -\frac{s^2}{k\mu} \quad \ldots\ldots [4]$$

It is the analytical solution of this equation which was asked for and the details are given here exactly as they appeared in Mr. Bratt's paper. In fairness to Mr. Bratt, however, we must point out that he made no claim to originality for any of the mathematics involved, since a solution of [4] applied to planetary motion has been known for two and a half centuries (Newton's Principia, 1687) and since Lord Rayleigh (Proc. Lond. Math. Soc., 1, xi, 57, 1880), proposed a method of solving viscosity problems by analogy with other physics problems of known solution. Rayleigh's suggestion applied to Galileo's falling-body problem yields a solution of [4] for the present case.

It will be recalled that the velocity V attained by a body in falling a distance h under a constant gravitational acceleration g is

$$V^2 = 2gh \quad \ldots\ldots [G1]$$

Now in the notation of the calculus

$$dh/dt = V \quad \ldots\ldots [G2]$$

$$d^2h/dt^2 = g \quad \ldots\ldots [G3]$$

and

$$2gh = 2\int gdh + C \quad \ldots\ldots [G4]$$

Using this notation Equation [G1] may be written:

$$(dh/dt)^2 = 2\int gdh + C \quad \ldots\ldots [G5]$$

which is the solution of [G3]. If the acceleration g is not constant but depends on h, Equation [G3] is replaced by

$$d^2h/dt^2 = f(h) \quad \ldots\ldots [G6]$$

and [G5] is replaced by

$$(dh/dt)^2 = 2\int f(h)dh + C \quad \ldots\ldots [G7]$$

[5] Shawinigan Water and Power Co.

[6] See MECHANICAL ENGINEERING, November, 1933, pp. 685–688.

which is the solution of [G6] for any acceleration whatever. If in [G6] we replace h by θ and t by y, we have:

$$d^2\theta/dy^2 = f(\theta)$$

which is Equation [4], if we note that $f(\theta) = -s^2/k\mu$. Hence, by analogy with [G7], the solution of [4] is:

$$(d\theta/dy)^2 = -2\int \frac{s^2}{k\mu} + C$$

Bratt's paper gave the more formal solution of [4] which occurs in many texts on differential equations as follows:

Multiply [4] by $2(d\theta/dy)$, which gives

$$2\frac{d\theta}{dy}\frac{d^2\theta}{dy^2} = -\frac{2s^2}{k\mu}\frac{d\theta}{dy}$$

But $$2\frac{d\theta}{dy}\frac{d^2\theta}{dy^2} = \frac{d}{dy}\left(\frac{d\theta}{dy}\right)^2$$

Hence we have: $$\frac{d}{dy}\left(\frac{d\theta}{dy}\right)^2 = -\frac{2s^2}{k\mu}\frac{d\theta}{dy}$$

which, upon integration, becomes:

$$\left(\frac{d\theta}{dy}\right)^2 = -\int \frac{2s^2}{k\mu}\,d\theta + C_1 \quad \ldots\ldots\ldots\ldots [5]$$

Now replace μ under the integral by its value from [1]. We have then:

$$\left(\frac{d\theta}{dy}\right)^2 = -\frac{2s^2}{k\mu_{20}}\int e^{+C(\theta-20)} = -\frac{2s^2}{k\mu_{20}C}e^{+C(\theta-20)} + C_1 \quad \ldots\ldots\ldots [6]$$

Now, when $\theta = \theta_m$, $\frac{d\theta}{dy} = 0$, hence

$$C_1 = \frac{2s^2}{k\mu_{20}C}e^{+C(\theta_m-20)}$$

and we have finally:

$$\left(\frac{d\theta}{dy}\right)^2 = \frac{2s^2}{k\mu_{20}C}\left[e^{+C(\theta_m-20)} - e^{+C(\theta-20)}\right] \ldots\ldots [7]$$

We can eliminate $d\theta/dy$ from [7] by substituting its value from [3]. We have then:

$$\frac{s^2(u-u_0)^2}{k^2} = \frac{2s^2}{k\mu_{20}C}\left[e^{+C(\theta_m-20)} - e^{+C(\theta-20)}\right]$$

or $$(u-u_0)^2 = \frac{2k}{C\mu_{20}}\left[e^{+C(\theta_m-20)} - e^{+C(\theta-20)}\right] \ldots\ldots [8]$$

This is the precise equation relating u and θ. It shows that the $u(\theta)$ function is symmetrical about the $u = u_0$ axis. Furthermore, all the other curves derived from this function are symmetrical about this axis or in the point u_0, θ_m. Since the space coordinate has disappeared entirely from the $u(\theta)$ function, it should be obvious that this symmetry is merely another example of the beautifully simple manner in which the Almighty has caused nature to function and is in no way related to Bratt's choice of coordinate axes. A careful interpretation of Mr. Kingsbury's equations will, of course, yield the same result. Bratt selected the simplest case so that the mathematically uninitiated might more easily follow the argument.

For values of θ and θ_m not differing greatly from 20 C, the exponentials in [8] can be expressed as power series and terms of second or higher order neglected. The result is:

$$\theta_m - \theta = \frac{\mu_{20}}{2k}(u-u_0)^2 \ldots\ldots\ldots\ldots [9]$$

This equation shows that the temperature rise in the film is independent of the thickness as Mr. Kingsbury points out. It also shows that the temperature rise for the symmetrical case is proportional to the square of the relative velocity, and to the ratio of viscosity to conductivity.

It was this result, no doubt, which led Mr. Bratt to investigate some of the properties of oils with particular reference to the effect of the variation of the ratio of viscosity to conductivity with temperature and other variables.

I think Mr. Bratt felt that his contribution to the theoretical aspect of the subject was in pointing out the profitableness of studying the ratio of viscosity to conductivity as he was unable to find any adequate discussion of it by any of the lubrication specialists previous to 1927.

JAMES A. DUNCAN.[7]

Brooklyn, N. Y.

Corrections to Paper by Carter and Ellenwood

TO THE EDITOR:

At the recent Annual Meeting of The American Society of Mechanical Engineers, preprints from the December, 1933, issue of *Combustion*, of the paper by W. A. Carter and F. O. Ellenwood entitled "The Thermal Performance of the Detroit Turbine Using Steam at 1000 Deg. Fahr." were distributed. Errors have since been noted in the values appearing in columns 19 and 21 of Table 6 Feedwater-Heater Performance Data. An errata sheet giving the correct values may be obtained from the writer.

W. A. CARTER.[8]

Detroit, Mich.

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of this Committee in Case No. 764 as formulated at the meeting of November 24, 1933, it having been approved by the Council. In ac-

[7] Brooklyn Edison Co., Inc.

[8] Technical Engineer of Power Plants, The Detroit Edison Co. Mem. A.S.M.E.

cordance with established practise, names of inquirers have been omitted.

CASE NO. 764 (*Special Rule*)

Inquiry: May a miniature boiler having no pressure parts other than the steam generating coil of tubing and having both the water supply and the gas fuel supply governed by a flow motor, and which cannot therefore comply with the provisions of Pars. M-11, M-13, and M-14 of the Code, bear the official Code symbol? If so, may the stampings be affixed on a plate substantially as provided in Par. H-120 since it is not practicable to apply the stamping on the pressure part of the boiler proper?

Reply: It is the opinion of the Committee that if the material used for the pressure parts of a miniature coil-type boiler complies with Code specifications and all applicable requirements of the Code for Miniature Boilers are observed, the required stampings for miniature boilers may be applied. These stampings may be placed on a separate non-ferrous plate not less than 3 in. by 4 in. size which shall be as irremovably attached as possible to the front of the boiler casing.

Errata

Notice is hereby given to purchasers of the 1933 A.S.M.E. Power Boiler Code that an omission appears in section (*b*) at the top of page 90. This section should read as follows:

(*b*) A distance on each side of the middle line of the actual thickness *m* of the shell equal to 3 times such actual thickness, except that in no case shall the limits extend along the tubular portion of a connection beyond the surface *NP* of the shell, or of the reinforcement if any, more than $2^1/_2$ times the thickness *n* of the tubular portion (lines *AB* and *DC* in the sectional views).

Correction slips to be pasted in the Code are available upon application to M. Jurist, A.S.M.E., 29 W. 39th St., N.Y.C.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PARS. P-194 and U-33. REVISE SIXTH SECTION OF PAR. P-194 AND THIRD SECTION OF PAR. U-33 TO READ:

Domes and manhole frames attached to shells or heads of boilers (pressure vessels) shall be designed in accordance with Par. P-268*b* (U-59*b*), WITH THE ADDITIONAL REQUIREMENT THAT THE WORKING STRESS IN TENSION OF RIVETS IN MANHOLE FRAMES HAVING A THICKNESS OF $^7/_8$ IN. OR LESS AND OF RIVETS IN DOME FLANGES SHALL NOT EXCEED 7200 LB PER SQ IN.

PARS. P-268*b* AND U-59*b*. DELETE THE FOLLOWING SECTION:

[The outside diameter of a riveted reinforcing ring or flange shall not be less than $1^1/_2$ times the diameter of the opening in the shell.]

SPECIFICATIONS S-2 FOR STEEL PLATES OF FLANGE AND FIREBOX QUALITIES FOR FORGE WELDING to be revised to conform with A.S.T.M. Specifications A 89-33.

SPECIFICATIONS S-25 FOR OPEN-HEARTH IRON PLATES OF FLANGE QUALITY to be revised to conform with A.S.T.M. Specifications A 129-33.

SPECIFICATIONS S-26 FOR HIGH-TENSILE STRENGTH CARBON-STEEL PLATES FOR PRESSURE VESSELS (Plates 2 In. and Under in Thickness) has been adopted, which is identical with A.S.T.M. Specifications A 149–33T.

SPECIFICATIONS S-27 FOR HIGH-TENSILE STRENGTH CARBON-STEEL PLATES FOR FUSION WELDED PRESSURE VESSELS (Plates Over 2 In. up to and Including 4 In. in Thickness) has been adopted, which is identical with A.S.T.M. Specifications A 150-33T.

PAR. H-12. ADD THE FOLLOWING SENTENCE:

FOR THE PURPOSE OF APPLYING TABLE H-1 TO A NON-CYLINDRICAL BOILER, THE EQUIVALENT SHELL DIAMETER SHALL BE TAKEN AS THE WIDTH OF THE UNSUPPORTED PORTION OF ANY PLATE.

TABLE H-1. REVISE HEADING OVER FIRST COLUMN TO READ:
Diameter OR WIDTH of Shell, Tube Sheet or Head

PARS. H-35 AND H-90. REVISE HEADING PRECEDING PAR. H-35 TO READ:

Setting and Installation REQUIREMENTS AND RECOMMENDATIONS, and the heading preceding Par. H-90 to read:
Installation REQUIREMENTS AND RECOMMENDATIONS.

PARS. H-39 AND H-92. ADD THE FOLLOWING:

IF THE SYSTEM IS EQUIPPED WITH AN OPEN EXPANSION TANK, AN INTERNAL OVER-FLOW FROM THE UPPER PORTION OF THE EXPANSION TANK MUST BE PROVIDED IN ADDITION TO AN OPEN VENT, THE INTERNAL OVERFLOW TO BE CARRIED WITHIN THE BUILDING TO A SUITABLE PLUMBING FIXTURE OR TO THE BASEMENT. IF THE SYSTEM IS OF THE CLOSED TYPE AN AIR-TIGHT TANK OR OTHER SUITABLE AIR CUSHION MUST BE INSTALLED THAT WILL BE CONSISTENT WITH THE VOLUME AND CAPACITY OF THE SYSTEM. THE CAPACITY OF THE CUSHION TANK MUST NOT BE LESS THAN THE FOLLOWING SIZES:

SQ FT OF EQUIVALENT DIRECT RADIATION INSTALLED	GALLON TANK
UP TO 350	18
UP TO 450	21
UP TO 650	24
UP TO 900	30
UP TO 1100	35
UP TO 1400	40
UP TO 1600	2–30
UP TO 1800	2–30
UP TO 2000	2–35
UP TO 2400	2–40

AND PROVISIONS MUST BE MADE FOR DRAINING IT WITHOUT EMPTYING THE SYSTEM.

FIG. U-17*b*—The text of this figure will be modified to require a minimum clearance distance of $^1/_2$ in. between the extreme edge of the weld and the line of head tangency. The illustration will be supplemented with a fourth view to show this clearance with an inserted plus head welded on the outside only.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets, and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Lubrication Engineering

PROCEEDINGS OF THE SEVENTH OIL POWER CONFERENCE DEVOTED TO LUBRICATION ENGINEERING, under the joint auspices of The Pennsylvania State College and the Lubrication Engineering Committee of the Petroleum Division, A.S.M.E. Published by the School of Engineering, Technical Bulletin No. 18, 1933. Paper, 6 × 9 in., 173 pp., illus., $0.75.

REVIEWED BY WILLIAM F. PARISH[1]

THE Pennsylvania State College, School of Engineering, has issued Bulletin No. 18 on the proceedings of the Seventh Oil Power Conference, devoted to lubrication engineering. The meetings were held May 25 to 26, 1933, at State College, Pa., under the joint auspices of the college and the Lubrication Engineering Committee of the A.S.M.E. Petroleum Division.

The papers cover the lubrication of heavy industrial machinery; in fact, the practical data for the papers are derived from the operation of the largest machines that have been built and that are in successful operation in this country.

J. G. O'Neil, chief chemist, U. S. Naval Engineering Experiment Station, in the first paper of the conference, says: "If progress in the science of lubrication is to be continued, the shortcomings of our present methods of testing lubricants must be recognized and new methods must be established which will serve as a foundation upon which future advances in lubrication can be made." He then gives the encouraging information that the Navy Department has noticed a marked improvement in the lubricating oils submitted to it during the last five years. This they record through their work-factor test, in which every oil is given a control laboratory test that measures, in terms of a work factor, the degree to which a lubricating oil resists deterioration and change during use under definite operating conditions. The service that an oil must perform in the lubricating system of the engines of a warship has been made the yardstick for purchase. The accelerated service test is carried out in a specially designed testing machine. Duplicates of this machine will be found in all of the main research laboratories in the oil industry, where the lubricants are being constantly studied. This indicates that as soon as practical testing methods for the lubricants are devised that represent some of the conditions of actual service, or that will allow some one important factor of lubrication to be shown under check conditions, there follows a steady improvement in the character of the lubricants. This is as it should be because the purchaser has a means to establish quality. The interesting instance is quoted of an aviator who insisted on having for his engine a heavy oil having a viscosity of 130 sec at 210 F. The experimental station wanted to know why such a heavy oil was necessary and made a test on a 400-hp Liberty motor, running under full load for 5 hr on each of a series of oils of reduced viscosity. It was found that an oil having a viscosity of 57 sec with a pressure of only 5 lb on the lubricating system showed the lowest oil and gasoline consumption.

The bulletin records tests on the Kingsbury bearing machine, to supply data to support the hydrodynamic theory of film lubrication. The results will be of importance to the designers of modern machines. The paper, by E. M. Barber and C. C. Davenport, Pennsylvania State College, is in the nature of a progress report covering tests being carried on at the State College experiment station, for the benefit of industry as a whole.

The paper by Walter D. Hodson, president, The Hodson Corporation, Chicago, deals with the lubrication of bearings and roll necks in steel mills. This large machinery presents manifold lubrication problems, many of which are only now being solved. Mr. Hodson has made a special study of this branch of lubrication engineering for many years. He has been able to show creditable results through use of a special form of extreme-pressure lubricant made with an inert fiber, the oils being classified as fibrous-structure oils. With bearings designed or changed for the use of these lubricants and with proper systems for applying them, the records given in the paper indicate power savings, increased life of equipment, increased production, and reductions in the cost of lubrication. It is refreshing to find this work has been done in mills using ponderous machinery, the lubrication of which is generally associated in the minds of most lubrication engineers with massive blocks of non-fluid lime greases, or, in the older days, with actual sides of pork and large hunks of tallow, applied with a shovel or hook and pounded down with a club, a practise which Mr. Hodson intimates has not entirely died out.

A session of the conferences devoted to lubrication-standardization brought forth a paper on viscosity classifications by A. E. Becker, Standard Oil Development Company, New York, N. Y., followed by another on the same subject by C. M. Larson, Sinclair Refining Co., New York, N. Y., and discussed by H. A. S. Howarth, Mayo D. Hersey, and others. All encouraged further work on the classification of industrial lubricants, working out some standard on a simple and practical system, which could be adopted for the general benefit of every one concerned. The conference requested the A.S.M.E. to

[1] Consulting Lubrication Engineer, New York, N. Y. Mem. A.S.M.E.

request the American Standards Association to develop such a system.

A paper by O. C. Bridgeman, U. S. Bureau of Standards, on extreme-pressure lubricants and one by Austin Kuhns, Farrell-Birmingham Co., Buffalo, N. Y., on problems of lubricating heavy gears, cover the subject from the points of view of theory, the designer of machinery gears, and the builder. These two papers, with the discussions by Messrs Hodson, Reswick, and others, cover much ground satisfactorily, and yet leave room for many other papers on the same subject, which, in so far as industrial gears are concerned, has not been overdone. Gears are elements in all types of machinery, and the most efficient manner of lubricating them has been neglected, according to remarks in these papers. It seems necessary for the practical lubrication engineer and the machinery designer to cooperate more closely, as their points of view are not always the same.

The lubrication of wire rope, an interesting and neglected subject, is expertly handled in the paper by A. J. Morgan, chief engineer, John A. Roebling's Sons Co., Trenton, N. J., and discussed by other wire-rope makers and rope-lubricant manufacturers. Excellent service data are produced, basic rules are laid down, and methods are suggested with much practise behind them for conserving the life of wire rope, making it safer, and operating it at less cost. This subject is further treated by L. M. Tichvinsky, of the Westinghouse research staff, who reported that special testing machines had been built and used for securing the coefficients of friction of working wire ropes under laboratory conditions. The results again show the practical value of properly lubricating such ropes.

The design and operation of the largest bearings in power turbines is discussed in a paper by T. W. Gordon, General Electric Company, Schenectady. The paper contains descriptions of the bearings of the hydraulic-turbines in Russia and this country. These bearings have an integral system of cooling and lubrication without which they would have but a short life. In fact, the lubricating system for each bearing seems to occupy much more attention and space than the bearing itself. But again, what is the use of designing and building great and expensive bearings for machines that are to do important work and not give the subject of lubrication all the thought and attention it deserves?

Books Received in the Library

A.D.B. RICHTLINIEN FÜR DEN VORRICHTUNGSBAU. Edited by Ausschuss für Vorrichtungen in der Arbeitsgemeinschaft deutscher Betriebsingenieure. V.D.I. Verlag, Berlin, 1933. Paper, 9 × 12 in., 28 pp., diagrams, tables, 2.80 rm. These papers are the first of a collection devoted to the design of machine-tool fixtures, to be issued by the Arbeitsgemeinschaft deutscher Betriebsingenieure. The present instalment discusses eccentric clamps and drill bushings. The form and purpose of these appliances are discussed briefly, the principles underlying correct design are set forth, and standard forms are given. Numerous illustrations assist in a clear, practical presentation of principles.

AERONAUTICAL AND MISCELLANEOUS NOTE-BOOK (ca. 1799–1826) OF SIR GEORGE CAYLEY, with an Appendix comprising a list of the Cayley Papers. Published for the Newcomen Society by W. Heffer & Sons, Cambridge (England), 1933. Papers, 7 × 9 in., 93 pp., illus., diagrams, 7s 6d. The note-book here reproduced was recently found among the papers of the Cayley family and is now published for the first time. Its chief importance lies in the notes bearing upon aeronautical matters, which record his observations and reflections on the mechanical laws of bird flight and his experiments in aerodynamics. As the greatest pioneer of modern aeronautical science, the first maker of a successful glider, and the first to suggest the application of the internal-combustion engine to aircraft, Cayley's work is of extreme interest.

ANTRIEBSVERHÄLTNISSE UND KRÄFTESPIEL AN BACKEN-STEINBRECHERN, INSBESONDERE AN GROSSBRECHERN. (Mitteilungen des Forschungsinstituts für Maschinenwesen beim Baubetrieb, Part 5.) By A. Bonwetsch. V.D.I. Verlag, Berlin, 1933. Paper, 8 × 12 in., 41 pp., illus., diagrams, charts, tables, 10.75 rm. This report covers an exhaustive study of jaw crushers, especially those of large size, undertaken to throw light upon the stresses during operation, power requirements, etc. Formulas are derived from the experimental data which are of interest to designers of crushers and manufacturers of motors.

ARMY ENGINEERING. By W. A. Mitchell. Third edition. Society of American Military Engineers, Washington, D. C., 1933. Leather, 4 × 7 in., 329 pp., illus., diagrams, tables, $3. This pocket-book covers the knowledge of engineering required of officers in the United States Army and is a revision of the course given in the First Class at the United States Military Academy. Mapping, shelters, roads, railways, bridges, fortification, camouflage, explosives, demolitions, siege works, chemical warfare, gasoline engines, power plants, seacoast defenses, and river and harbor works are discussed from the military viewpoint.

A.S.T.M. STANDARDS ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS. (Paints, Varnishes, Lacquers, and Paint Materials.) Prepared by Committee D-1 on Preservative Coatings for Structural Materials, October, 1933. American Society for Testing Materials, Philadelphia. Paper, 6 × 9 in., 350 pp., illus., diagrams, tables, $1.25. The specifications, methods of testing, and definitions for paints, varnishes, lacquers, and paint materials which have been adopted by the Society are collected in this volume in convenient form for use by the paint and varnish industry.

ATLAS METALLOGRAPHICUS. No. 12, Tables 89–96; No. 13, Tables 97–104; No. 14, Tables 105–108. By Hanemann and Schrader. Gebrüder Borntraeger, Berlin, 1933. Paper, 8 × 11 in., illus., charts, tables. No. 12, subscription price, 7 rm., single price, 14 rm.; No. 13, subscription price 7 rm., single price 14 rm.; No. 14, subscription price, 8 rm., single price 16 rm. This great metallographic atlas is intended to provide a complete collection of photomicrographs of the structure of metals and alloys, for purposes of comparison. These instalments complete the volume devoted to slowly cooled and annealed carbon steels. It contains over 800 photomicrographs, with information about the magnification, etching reagent and the nature of the specimen, and remarks on the structure shown. An introduction explains the iron-carbon diagram, discusses the occurrence of various constituents and late theories concerning them.

AUTOMOTIVE ENGINES, Design, Production, Tests. By P. M. Heldt. (Eighth edition of The Gasoline Motor.) P. M. Heldt, Nyack, N. Y., 1933. Cloth, 6 × 9 in., 598 pp., illus., diagrams, charts, tables, $6. Numerous changes distinguish this work from previous editions, which were issued under the title, "The Gasoline Motor." The chapters on Diesel type, two-stroke, sleeve-valve, and offset engines have been omitted. A chapter has been added on torsional vibration and vibration dampers, and the chapter on the determination of bearing loads has been rewritten. Other chapters have been extensively revised in accordance with changes in engine design. The book discusses engine design, production, and testing in a thorough, practical manner.

AUTOMOBILE ELECTRICAL EQUIPMENT. By A. P. Young and L. Griffiths. Iliffe & Sons, Ltd., London, 1933. Cloth, 6 × 9 in., 336 pp., illus., diagrams, charts, tables, 15s. The electrical equipment used in association with the internal-combustion engine, for travel on land and sea, and in the air, is thoroughly covered in this book. Dynamos, starting motors, batteries, automobile lighting, and ignition systems are discussed in detail, with emphasis upon the principles that underly the evolution of design. The principal types of British machines are described and illustrated.

BOOK OF STAINLESS STEELS, Corrosion-Resisting and Heat-Resisting Chromium Alloys. Edited by E. E. Thum. American Society for Steel Treating, Cleveland, Ohio, 1933. Cloth, 6 × 9 in., 631 pp., illus., diagrams, charts, tables, $5. The manufacture, properties, and uses of corrosion and heat-resistant chromium alloys are discussed in this book, in which a large number of authorities have collaborated. Methods of production and fabrication used in America are described in detail; the properties of the typical alloys are presented, and the requirements of a large number of consuming industries are explained. A useful classified list of trade names is included. Metallurgists and makers and users of these steels will find the book very useful.

DREI KLASSIKER DER STRÖMUNGSLEHRE. (Ostwald's Klassiker der exakten Wissenschaften, No. 237.) By Hagen, Poiseuille, and Hagenbach; Edited by L. Schiller. Akademische Verlagsgesellschaft, Leipzig, 1933. Cloth, 5 × 8 in., 97 pp., diagrams, tables, 5.60 rm.

In 1843, a commission appointed by the Académie des Sciences reported upon Poiseuille's discovery of the "law" governing flow in small pipes. That discovery, however, had been anticipated in a paper by G. Hagen, published in 1839. In 1860, E. Hagenbach published an account of his studies on viscosity, the first completely correct solution of the problem of viscosity to appear. These three papers, of importance in the history of hydrodynamics, are here republished, with biographic and explanatory notes.

ELECTRICAL ENGINEERING PRACTICE, a Practical Treatise for Electrical, Civil, and Mechanical Engineers. Vol. 3. By J. W. Meares and R. E. Neale. Fourth edition. Chapman & Hall, London, 1933. Cloth, 6 × 9 in., 920 pp., illus., diagrams, charts, tables, 30s. This work is designed to provide students and engineers with a survey of the whole field of electrical engineering which will occupy a position between the pocket-book of bare data and the highly technical works written for the specialist. The purpose has been carried out very successfully, the three volumes covering the generation, distribution, and uses of electricity in a practical way. In volume three, electrical motors and their control, and the applications of electrical energy in industrial operations and processes, in traction and marine propulsion, and in agriculture are fully described. Specifications, testing, rules, and regulations are also considered. Good bibliographies accompany each chapter.

ELEMENTARY ENGINEERING THERMODYNAMICS. By T. H. Taft. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 229 pp., diagrams, tables, $2.75. A text-book covering the theory of fundamentals and some applications with special attention to points not easily understood by beginners. It is intended for brief courses in thermodynamics or heat engineering.

GREAT MEN OF SCIENCE, a History of Scientific Progress. By P. Lenard, translated from second German edition by H. S. Hatfield. Macmillan Co., New York, 1933. Cloth, 6 × 9 in., 389 pp., illus., $3. A distinguished scientist here presents an account of the lives and works of sixty-five men who "have brought forward something entirely new, having an essential bearing on our knowledge of nature, on our view of the universe and the position of man in nature." These men are presented in a most interesting way, and their works are shaped into a picture of the development of science in which each man is carefully evaluated. In spite of the small number of names, Professor Lenard asserts that "we find that the whole of our knowledge of nature, as far as it is of fundamental philosophic importance, is discussed." An unusual and valuable book.

"HÜTTE" DES INGENIEURS TASCHENBUCH, Vol. 3, No. 1. Edited by Akademischer Verein Hütte. Twenty-sixth edition. Wilhelm Ernst & Sohn, Berlin, 1933. Paper, 5 × 8 in., 676 pp., diagrams, charts, tables, 10 rm. Volume three of "Huette" is devoted to civil engineering. The twenty-sixth edition will appear in two parts, of which the first is now on sale. It treats of statics, of construction, foundations, earthwork, tunneling, reinforced concrete, framed structures, heating, ventilation, factory buildings, hydraulic works, water supply, and sewerage. Each subject has been thoroughly revised.

INTRODUCTION TO THEORETICAL PHYSICS. By J. C. Slater and N. H. Frank. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 576 pp., diagrams, charts, tables, $5. This textbook presents the classical and the more modern parts of theoretical physics as a coherent whole, and is intended to familiarize the reader with the methods and principles of the subject, and enable him to read advanced books on its various branches. A knowledge of descriptive physics and mathematics through the calculus is assumed.

THE INVENTOR AND HIS WORLD. By H. S. Hatfield. E. P. Dutton & Co., New York, 1933. Cloth, 5 × 8 in., 269 pp., diagrams, $2.40. Starting with a discussion of what invention is, the author then proceeds to indicate the temperament characteristic of the inventor, to show how he works, to explain why it is so difficult for him to get his invention adopted, and to indicate promising directions for his efforts. Mechanical, chemical, electrical, biological, and psychological inventions are discussed quite fully, and the workings of patent law are considered. There is a good bibliography. The treatment is practical and philosophical, and the book is a distinct addition to the literature on the subject.

LOKOMOTIVEN MIT ANTRIEB DURCH DAMPF, DRUCKLUFT UND VERBRENNUNGSMOTOREN. (Sammlung Göschen 1073.) By E. Metzeltin. Walter de Gruyter & Co., Berlin and Leipzig, 1933. Cloth, 4 × 6 in., 126 pp., illus., diagrams, charts, tables, 1.62 rm. The principles of locomotive design and construction are briefly outlined, and illustrated by current types. Steam locomotives are given chief consideration, with brief discussions of compressed-air and internal-combustion engines.

LUFTFAHRTFORSCHUNG, Vol. 10, No. 2, July, 1933. R. Oldenbourg, Munich and Berlin. Paper, 8 × 12 in., pp. 55–86, diagrams, charts, tables, 6 rm. This number presents the results of a study of the behavior of structural members under dynamic stresses, carried on jointly by the national aircraft research laboratories of Holland and Germany.

LUFTFAHRTFORSCHUNG, Vol. 10, No. 3, October, 1933. R. Oldenbourg, Munich and Berlin. Paper, 8 × 12 in., pp. 87–144, illus., diagrams, 7 rm. This brochure discusses comprehensively the breathing of the avaiator. The changes in the process of breathing induced by changes of air pressure are first considered, after which the effects of flying upon the physiological and nervous functions are considered. Methods for preventing harmful effects are indicated.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN DES GHH-KONZERNS. Vol. 2, No. 8, October, 1933. (1) Nebenverbrauche einer Dampfförder-maschine, by E. Nalbach; (2) Untersuchungen über das Verhalten der Schaufelspaltdichtungen in Gegenlauf-Dampfturbinen, by H. Friedrich. V.D.I. Verlag, Berlin, 1933. Paper, 9 × 12 in., illus., diagrams, charts, tables, 4.50 rm. The first paper here presented gives the results of a test of the heat consumption of a modern mine-hoisting plant under practical conditions, in which account is taken of pipe-line losses, idle time, etc. The second paper supplements Dr. Hofer's recent study of flow phenomena in steam turbines, by an investigation of the clearance width in turbines and a development of methods for its measurement.

MITTEILUNGEN DES INSTITUTES FÜR STRÖMUNGSMASCHINEN DER TECHNISCHEN HOCHSCHULE KARLSRUHE, No. 3. Edited by W. Spannhake. V.D.I. Verlag, Berlin, 1933. Paper, 8 × 11 in., 92 pp., illus., diagrams, charts, tables, 3 rm. This pamphlet contains (1) a study of the regulation of radial-flow turbines by adjustable impeller vanes; (2) an investigation of the stresses produced in a rapidly rotating disk by an eccentric centrifugal force; and (3) an investigation of flow in a turbine pump, in which a simple method of making the flow visible is described.

MODERN THERMODYNAMICS BY THE METHODS OF WILLARD GIBBS. By E. A. Guggenheim, with a preface by F. G. Donnan. Methuen & Co., London; E. P. Dutton & Co., New York, 1933. Cloth, 6 × 9 in., 206 pp., diagrams, $3.50. The science of thermodynamics, as a branch of mathematical physics, was developed in an exact and comprehensive form in Gibbs's famous paper, but its highly condensed and abstract form has been difficult for students. This book is intended to make the analytical method which he developed more easily comprehensible. At the same time the treatment has been extended over solutions of the most general type and modern concepts and functions have been related to the chemical potentials of Gibbs.

NAVAL ORDNANCE, a textbook prepared for the use of the Midshipmen of the United States Naval Academy. United States Naval Institute, Annapolis, Md., 1933. Cloth, 6 × 10 in., 725 pp., illus., diagrams, charts, tables, $6. This textbook represents the course given to the midshipmen of the United States Naval Academy and has been prepared by officers of the Navy. In this revision incorrect and obsolete material has been eliminated, and the text has been amplified where neccessary and brought up to date.

ORIGIN AND ENVIRONMENT OF SOURCE SEDIMENTS OF PETROLEUM. By P. D. Trask, assisted by H. E. Hammar and C. C. Wu. Gulf Publishing Co., Houston, Texas, 1932. Cloth, 6 × 9 in., 323 pp., maps, diagrams, charts, tables, illus., $6. This report contains the final results of an investigation of the conditions under which sediments are now accumulating which in the future may be source beds of petroleum. The investigation occupied the years 1926–1932 and was sponsored by the American Petroleum Institute. The distribution of organic matter in various sediments and its composition, the physical conditions of accumulation of the mineral constituents of sediments were the principal problems studied. The data obtained are presented in detail, with the author's deductions.

PRINCIPLES OF METALLURGY. By D. M. Liddell and G. E. Doan. McGraw-Hill Book Co., New York and London, 1933. Cloth, 6 × 9 in., 626 pp., illus., diagrams, charts, tables, $5.50. In preparing this book the authors have attempted to present the subject in a way that will meet the needs of engineering students who do not intend to pursue metallurgy as a life work, and will also give future metallurgists a proper foundation for their vocation. The subject is treated under three

heads: materials consumed, extractive processes and apparatus, and physical metallurgy. The treatment is basic and the importance of economic factors is emphasized constantly. In addition to its use as a text, the work will be useful as a compact reference book for principles, processes, and important data.

QUALITÄTSTEIGERUNG IM WERKZEUG- UND FEINMASCHINENBAU, Gedanken und Vorschläge. By C. Büttner. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 9 in., 22 pp., illus., diagrams, charts, tables, 1.90 rm. The first section of this book is a critical consideration of methods of precision turning, grinding, and lapping, with suggestions for their improvement. The second section discusses precision machine tools and their elements in similar fashion and gives methods for testing their adaptability for precise work. The book appeared serially in "Maschinenbau."

ROMANCE OF RESEARCH. By L. V. Redman and A. V. H. Mory. Williams & Wilkins Co., Baltimore, 1933. Cloth, 5 × 8 in., 149 pp., charts, $1. This readable, interesting little book aims to acquaint the general reader with the story of modern research work. The viewpoint and method of the research worker are discussed, the development of research during the last half-century is described, and some important contributions to human welfare are noticed.

VARIATIONSRECHNUNG, Vol. 1. (Sammlung Göschen 1074.) By L. Koschmieder. Walter de Gruyter, Berlin and Leipzig, 1933. Cloth, 4 × 6 in., 127 pp., diagrams, 1.62 rm. The first section of a very concise introduction to the calculus of variations, for students acquainted with the principles of differential and integral calculus. The present volume discusses only the simpler problems but is intended to equip the reader to handle these.

WHAT'S GOING ON

A.S.M.E. Transactions for January, 1934

THE January issue of the Transactions of the A.S.M.E., which, under the new plan approved by Council at its December, 1933, meeting, will combine all of the sections previously issued independently and which is being sent to every member in good standing now registered in any of the professional divisions, contains the following papers:

Effect of Fillets on Wing-Fuselage Interference (AER-56-1), by A. L. Klein

Field Welds in Pressure Pipe Lines of Steam Systems (FSP-56-1), by H. N. Boetcher

Roller-Bearing Service in Locomotive, Passenger, and Freight Equipment (RR-56-1), by T. V. Buckwalter

Dry Film Gluing in Plywood Manufacture (WDI-56-1), by Ray Sorensen.

A.S.M.E. Nominating Committee

THE 1934 Nominating Committee, Collins P. Bliss, chairman, asks for suggestions of names of men qualified to fill the offices of president, vice-president, and manager of the A.S.M.E. These names should be sent promptly to the secretary of the A.S.M.E. Nominating Committee so that they may be given thorough consideration prior to the A.S.M.E. Semi-Annual Meeting in Denver, Colo., June 25, 1934. The committee will hold open sessions at Denver to receive oral suggestions.

The selection of Society officers is an important task, and the Nominating Committee asks the cooperation of the individual members of the Society in guiding its deliberations.

Officers should be men of prominence and leadership, with time to devote to Society affairs. Previous service on committees and consequent knowledge of Society affairs is a factor of importance. The president and vice-presidents must be of the member grade; managers may be of any grade of membership. Suggestions may be sent to the secretary of the committee, Prof. J. M. Foster, North Carolina State College, Raleigh, N. C.

Greater New York Safety Conference

THE Fifth Annual Greater New York Safety Conference, under the auspices of the Metropolitan Chapter, American Society of Safety Engineers, the Engineering Section, National Safety Council, and 52 cooperating organizations, will be held at the Pennsylvania Hotel, New York, N. Y., March 6 and 7, 1934. The two-day program of the conference is made up of 15 sessions at which 45 speakers will present papers, with a banquet on the evening of March 7.

Unfired Pressure Vessels for Petroleum Liquids and Gases

DURING the past month the API-ASME Rules for the Design, Construction, Inspection, and Repair of Unfired Pressure Vessels for Petroleum Liquids and Gases were submitted to the American Petroleum Institute and The American Society of Mechanical Engineers, the sponsors for the joint committee which prepared this material. This committee was appointed in December, 1931, and has worked intensively during the past two years in developing and revising these rules. In all, ten drafts of the rules were prepared, some of which were broadly distributed for criticism and comment.

The A.S.M.E. Boiler Code Committee favors the publication of these rules for comment and criticism. Following which the Boiler Code Committee plans to review them with the idea of adoption in the present or a revised form for incorporation in its Code for Unfired Pressure Vessels.

At the present time some copies of the printer's proofs are still available for those who are especially interested in this subject and would wish to review the rules and to give the joint committee and the A.S.M.E. Boiler Code Committee the benefit of their suggestions. Copies may be secured, as long as they last, by addressing Mr. C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Metal-Cutting Bibliography Projected

IN 1930 The American Society of Mechanical Engineers published a bibliography on the cutting of metals, compiled by Prof. O. W. Boston, of the University of Michigan. It included some 770 references with short abstracts and covered the period from 1866 to 1930. Since the publication of this bibliography, Professor Boston has compiled an additional 990 references with abstracts, bringing the work up to date. The work is prepared for lithoprinting in the same general form as the A.S.M.E. publication, and will be published if there is sufficient demand for it. It will sell at a price covering the cost, not to exceed two dollars, depending upon the number of copies required. Those wishing copies may communicate directly with Professor Boston, University of Michigan, Ann Arbor, Michigan. For an additional 75 cents, a copy of the A.S.M.E. bibliography may be obtained.

Actions of the A.S.M.E. Executive Committee

AT THE meeting of the Executive Committee of Council of A.S.M.E. on January 13, 1934, F. W. Weed, Assistant Deputy Administrator of the N.R.A., explained the present status of that part of the Construction Code dealing with the engineering division of the construction industry.

CODE DRAFTING

He said that the National Industrial Recovery Act is essentially an industrial act. It is difficult to apply it to a profession. However, the engineering activity in the construction industry being a large and important part of that industry, it seemed to be a necessary consequence that the engineering phases of the construction industry should be brought within the limits of a code.

Mr. Weed reported that all of the drafts of the code which had been drawn up to date had been discarded and that, at the present time,

a completely new draft was in preliminary form for discussion and development. Mr. Weed explained some of the difficulties inherent in the prastise of engineering in the construction industry brought about by the fact that there are several classes of engineers engaged in the construction industry. For example, there are organizations and individuals who undertake to provide impartial engineering service, designing and supervising the construction of a building or a large project without performing the services of a contractor. Then there is a second group, the engineer constructor who provides and is responsible for the engineering services in connection with construction and is also responsible for the actual construction. Then there is the engineer who is interested in a special process or a particular type of engineering design or equipment who will undertake to provide engineering service in the construction industry but will, of course, supply the product that he manufactures. Other groups that may come under the provisions of the engineering division of the code are those engaged in sales engineering, engineering inspection, and in surveying.

Mr. Weed took particular pains to point out that a code for the engineering division of the construction industry was a means for providing jurisdiction over firms or responsible individuals in engineering whose relationships with each other, the architectural profession, the contractors, and the other elements in the construction industry would be subject to misunderstandings and require control. The code itself is not intended to provide for the control or the representation of the individual engineers. It is hoped that the code will be set up in such a manner that most engineers will fall into the skilled class, so that the minimum wages, which are regarded as those of laborers, will not apply to engineers at all. Mr. Weed pointed out that in these matters there is a great deal of misunderstanding and that it is important that every one understand the scope and purpose of the code if it is to work out properly.

There was some discussion about the form of control authority for the code. Mr. Weed pointed out that it is usual for each element that is affected by the code to have representation on the divisional code authority. It is, however, also necessary from the point of view of the NRA that a single responsible body be assigned the complete authority so that the NRA can be assured of prompt and thorough action in all matters relating to the code.

After the discussion the Executive Committee voted to extend its complete cooperation in the preparation of the code of the engineering division of the construction industry and President Doty was given the power to appoint representatives on the groups engaged in its preparation as occasion requires.

COMMITTEES, DIVISIONS, AND APPOINTMENTS

Other matters of unusual importance were taken up. A progress report of the Committe on Capital-Goods Industries was received and authorized published. This report appears in this issue of MECHANICAL ENGINEERING.

The organization of the Process Division was authorized with the understanding that there would be no additional expense to the Society.

The fact that the student-branch development plan had been extended over more than two-thirds of the country was considered to be grounds for referring to the Committee on Constitution and By-Laws the incorporation in the formal laws of the Society of the temporary by-laws and rules that have been set up to govern this development scheme.

D. Robert Yarnall was appointed to represent the A.S.M.E. on the United Engineering Trustees, W. H. Fulweiler on Engineering Foundation, and C. W. Spicer on the Standards Council of the American Standards Association.

Other matters of administrative importance dealt with the budget for the current year, the classification of members in arrears and the payment of their dues, and the establishment of prices for Transactions in the new form.

The recommendation that the A.S.M.E. participate in the project for redefining the standard ton of refrigeration was approved, and George B. Bright, of Detroit, was appointed to represent the Society on this committee.

It was reported that in response to President Doty's letter of December 12 to the members of the A.S.M.E. many expressions of approval had been received. With these were also numerous suggestions from members. The Committee expressed its gratification at these evidences of approval of President Doty's letter, and is giving careful consideration to the many helpful suggestions that have been received.

The next meeting of the Executive Committee will be held in Cincinnati on March 3. The officers traveling to that meeting plan to visit the individual Sections en route. A representation of Council will be present at the Colorado Meeting in the latter part of June and a full meeting of Council with representatives of all standing committees will be held at Purdue University shortly thereafter.

Proposed Correlated A.S.M.E.-A.S.T.M. "Creep" Program

THE A.S.M.E.-A.S.T.M. Joint Research Committee on Effect of Temperature on the Properties of Metals discussed at a recent meeting the problem of correlating long-time research-type "creep" test methods with rapid shop or acceptance-test methods.

The logical base line for high-temperature design is the stress for a given amount of deformation, determined by tests, each at one constant temperature and one constant load. This requires a family of curves obtained by long-time "creep" tests.

As is usual in the development of a new type of testing, early results were shrouded in uncertainty because it was not clear whether the discrepancies and discordances in the results of different observers were due to inaccuracies in the method of test, or to real differences in supposedly similar lots of material. The testing difficulties appear well on the way toward being smoothed out by the promulgation last June of a Tentative Creep Test Code which summarizes in a few essentials of procedure the experience of the committee members and of those of its many subcommittees. Thus the way is paved for true appraisal of the actual differences among materials and, in the case of a single material, of the determination of its load-carrying properties. Determination of the spread in load-carrying ability between different lots of material of the same class, so that the designer can intelligently fix "safe loads"—for which the user is clamoring—must await the accumulation of data on lots of known history.

IMPATIENCE OF DESIGNERS

In most cases design cannot wait for this accumulation, so the designer has to make the best guess he can. He knows that the short-time high-temperature tensile test by itself gives high values, which, if they have any real value at all in design for structures to be subjected to long loading, must certainly be modified by large factors of safety which must increase, as the temperature is increased, and increase to such large magnitudes that the shakiness of the assumptions made becomes self-evident. The designer feels more security in having creep values, from, say, 1000-hr tests, as a basis for extrapolation to the years of actual service he desires, but at best he must still extrapolate and must, while lacking actual data, make assumptions as to the conformity of the behavior of the material he uses with available data for behavior of other material of that type that has been previously tested.

Pressure is therefore put on the testing engineer to provide quicker returns when a given lot of material is submitted for high-temperature appraisal. The suggestions for short-cuts have been many.

Proponents of suggestions for short-cuts normally advocate them primarily for "sighting shots" to reduce the necessary number of creep tests, or for appraisal of the uniformity of a given material from lot to lot rather than as a true foundation for design values, but either the proposer of the short-cut or some one who reads or hears of it, ultimately attempts to find some conversion formula by which the short test can be made to tell the long story.

Either some such conversion is possible, or none is. Progressive engineers have an open-minded attitude toward accelerated methods, but at the same time one that demands engineering proof of, instead of mere hope of, correlation.

The correlation of long-duration, research-type test methods and rapid shop or acceptance test methods was one of the original purposes for which the A.S.M.E.-A.S.T.M. Joint Committee was formed and which has had constant consideration in its councils. The committee is therefore suggesting that a correlation program should be undertaken wherein, as a minimum, one ferritic and one austenitic steel, each most carefully chosen for metallurgical uniformity and stability, would be subjected to creep determinations, at a temperature in each case chosen in view of the

recognized uses for such materials at those temperatures, and at three loads, chosen to produce creep rates of the order considered allowable in industrial use. These creep tests would continue for *three years* and be made under all the refinements of the A.S.T.M.-A.S.M.E. Tentative Code.

Meanwhile, the same materials would be subjected to the various accelerated or short-cut methods that have been proposed, and various methods of extrapolation from one load to another that have been suggested, would be applied. From these methods the rate of creep for three years would be predicted according to the procedure used by the proponents of each method, and later compared with the actual results of the three-year test. Material would be held for use in other short-cut methods that may arise later, and for possible international comparisons of methods.

Instead of waiting for comparisons of each short method with regular creep to be made upon whatever materials the experimenter has available, with consequent difficulty of correlation, *simultaneous* correlation would thus be obtained on the *same* materials.

Obviously, such a program would involve considerable expense, though the committee already has the promises of many of its own members for cooperation in the program, and the minimum program outlined could not be started without assurance of sufficient interest and support to make its completion certain.

COMMENTS ON PROGRAM SOLICITED

Designers and users, as well as producers, of alloys for high-temperature equipment, such as the power plant, oil, and furnace industries, are therefore invited to inform the secretary of the Joint Committee, N. L. Mochel, Westinghouse Electric & Manufacturing Company, Lester Station, Philadelphia, Pa., whether they would like to see such a correlation program taken up by the Joint Committee. The committee desires to be as responsive to the wishes of the interested engineering industries as the available financial resources will allow. While its own membership feels that the project outlined should be undertaken at the earliest feasible moment, before committing itself to a "three year plan," it seeks comment and guidance on the selection of this or alternate activities that may be deemed more pressing by the engineering world. The committee will not assume, in the absence of either adverse or favorable comment, that "silence gives consent." Should the program not be sufficiently welcome to the industries concerned so that a definite desire for its pursual is registered with the committee, the project will not go forward. Comments to Mr. Mochel are therefore earnestly requested, whether pro or con. The comments will be considered at an early meeting of the committee.

TRANSACTIONS APPEARING MONTHLY

As announced in January (see page 35), the various sections of the A.S.M.E. Transactions are being combined, and issued monthly as a periodical publication to be distributed to every member of the Society in good standing who wishes to receive it.

The new plan requires no action on the part of members who are registered in one of the Divisions and are now receiving any section of the Transactions. Any other member in good standing who is not registered in one of the Divisions and who would like to receive Transactions monthly should ask to have his name placed on the mailing list. Address requests to The Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Coming Meetings of A.S.M.E. Local Sections

Chicago: February 12. Joint Meeting with the Western Society of Engineers, Wacker Drive and Wells St., at 7:30 P.M. Subject: An American Engineer's Five Years' Experience in Russia, by Gordon Fox, Freyn Engineering Company.

Hartford: February 13. State Trade School, 110 Broad St., at 8:00 P.M. Subject: Testing Aviation Motors, by Lewis McClain, Test Pilot, Pratt & Whitney Aircraft Company.

Louisville: February 16. Engineers and Architects Club, Louisville, Ky., at 8:00 P.M. Subject: Air Conditioning, by H. C. Murphy, Reed Air Filter Company.

Metropolitan: February 7. Room 502, Engineering Societies Building, 29 West 39th St., New York City, at 8:00 P.M. Sponsored by Power Division, A.S.M.E. Subjects: Some Problems in the Removal of Sulphur Dioxide From Flue Gas, by C. E. Scott, Columbia University, CO_2 Recovery From Flue Gases, by D. H. Killefer, contributing editor, *Industrial and Engineering Chemistry*.

February 7. Room 1101, Engineering Societies Building, 29 West 39th St., New York, N. Y., at 8:00 P.M. Sponsored by Management Division, A.S.M.E. Subject: Recent Trades in Personnel Relations, by Dr. Henry C. Metcalf, consultant in personnel relations.

February 15. Room 502, Engineering Societies Building, 29 West 39th St., N. Y. at 8:00 P.M. Sponsored by Oil and Gas Power Division, A.S.M.E. Subject: The Cost of Diesel Generated Power.

February 21. Room 1101, Engineering Societies Building, 29 West 39th St. at 8:00 P.M. Sponsored by Management Division, A.S.M.E. Subject: Marketing Research, by R. L. Gibson, manager of market research division, General Electric Co., Schenectady, N. Y.

Ontario: March 9. University of Toronto Mining Building, at 8:15 P.M. Subject: Centrifugal Pumps, Motors, and Electric Control, by P. L. Evans, Pump Design Engineer, Babcock-Wilcox and Goldie-McCulloch, Ltd.

Providence: February 6. Rooms of the Providence Engineering Society at 8:00 P.M. Subject: The Treatment of Water for Household, Industrial and Municipal Uses, by S. B. Applebaum, Vice-President, Permutit Company, New York, N. Y.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 26, 1934, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Members desiring further information, or having comments and objections, should write to the Secretary of the A.S.M.E. at once.

NEW APPLICATIONS

ALBERGA, GLENN H., Pawtucket, R. I.
BALDWIN, PRESTON DEG., New York, N. Y.
BARTRAM, PAUL R., Fort Gay, West Va.
BENEDEK, E. K., Mount Gilead, Ohio
BROWN, HOWARD M., Philadelphia, Pa.
CARLSON, HAROLD C-R., Brooklyn, N. Y.
CARLSON, HENRY G., Jamestown, N. Y.
DINGLE, R. JACK, Fargo, N. D.
DOLESH, F. J., Rahway, N. J.
FARNHILL, EDWARD S., Coventry, England
FRANKENHOFF, EUGENE THEODORE, Chicago Ill.
FUCHS, ADOLPH, Bronx, N. Y.
GEDDES, L. H., Rockford, Ill.
HALBFASS, ARNOLD J., Berlin, Germany (Rt & T)
HETZEL, LOWELL H., Washington, D. C.
HIGGINSON, EDMUND E., Chicago, Ill.
JACOBSON, SAUL BAUM, Cambridge, Mass.
JOHNSON, EDWARD W., Port Richmond, N. Y.
JOHNSTONE, CHARLES A., Seattle, Wash.
LEE, EDWARD R., JR., East Orange, N. J.
MACLEOD, NORMAN D., East Providence, R. I.
MARINO, DOMINIC A., New York, N. Y.
MOLNAR, ERNEST, Columbus, Ohio
RILEY, RUSSELL A., St. Albans, L. I., N. Y.
SASSER, J. W., Princeton, W. Va.
SHAVER, P. E., Philadelphia, Pa.
THOMPSON, J. GEORGE H., Philadelphia, Pa.
WHITELEY, S. M., Baltimore, Md. (Rt & T)
WOELBING, GEORGE H., Denver, Colo.
WORCESTER, WARREN B., San Diego, Calif.
WYLIE, JOHN S., Terminal Island, Calif.

CHANGE OF GRADING

Transfers from Associate

BACH, GEORGE W., Erie, Pa.

Transfers from Associate-Member

ARTHUR, RUSSELL W., Rochester, N. Y.
JOHNSON, ROY E., New York, N. Y.
MORGAN, ALVA B., Darien, Conn.
O'NEILL, G. W., Amherst, Nova Scotia

Transfers from Junior

KOENIG, LLOYD R., Webster Groves, Mo.
POPE, LYMAN B., Haverhill, Mass.
RAISCH, WILLIAM, Forest Hills, L. I., N. Y.
SMITH, R. MOEN, Leominster, Mass.
ZOBER, WALTER, Brooklyn, N. Y.

ELESCO SUPERHEATERS
LJUNGSTRÖM AIR PREHEATERS

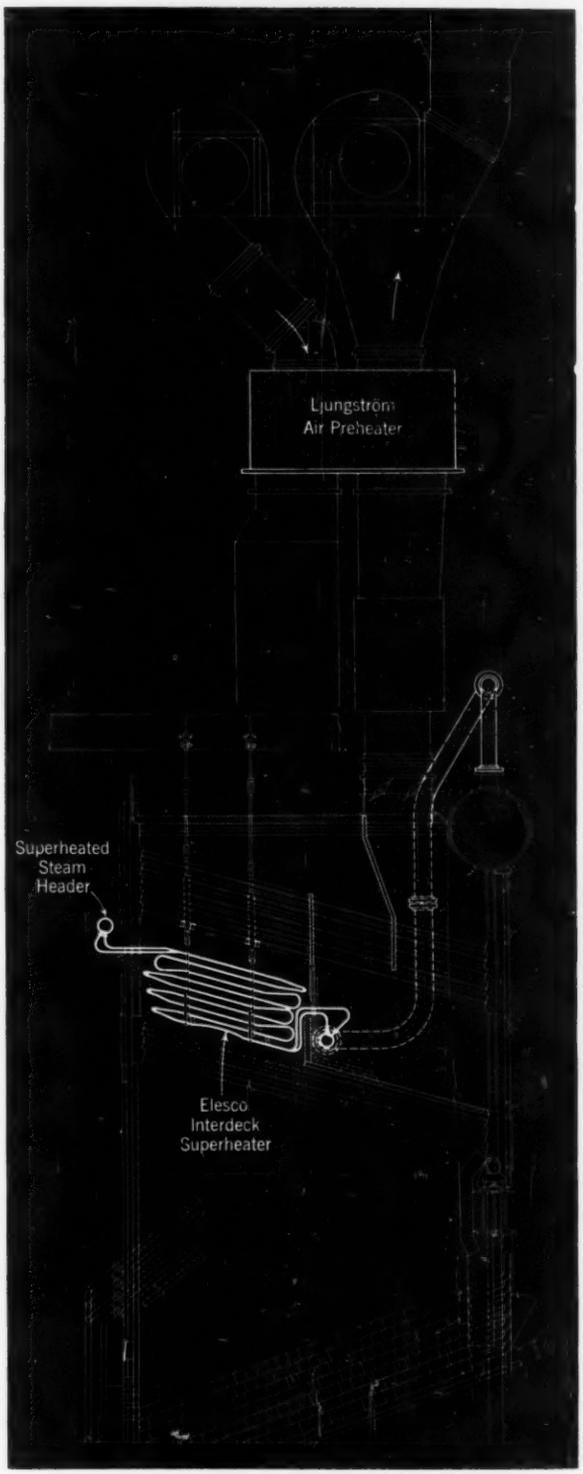
In Harding Street Station,

Indianapolis
Power and Light Company

During 1930 Indianapolis Power and Light Company added eight stoker-fired boilers, each equipped with an Elesco superheater and a Ljungström air preheater. This installation is representative of modern steam generating practice, with high-pressure, high-temperature steam, and preheated air for combustion.

• • • •

Elesco superheaters and Ljungström air preheaters are obtainable in types, sizes and arrangements to fit any set of operating conditions, as to kind of fuel and method of firing; size and type of steam generating unit; steam and combustion conditions.



Eight 1181-hp. Springfield cross-drum boilers, stoker-fired, equipped with Elesco interdeck superheaters and Ljungström air preheaters for the following conditions:

Steam temperature	725 deg. F.
(Superheat	268 deg. F.)
Pressure	440 lb. per sq. in.
Evaporation	124,000 lb. steam per hr.
Exit gas temperature	278 deg. F.
Preheated air temperature	311 deg. F.

THE SUPERHEATER COMPANY
THE AIR PREHEATER CORPORATION
60 East 42nd Street, New York

Canada: The Superheater Company, Limited, Montreal

Representatives in all large industrial centers

A-834

...and in a Baltimore Plant of Western Electric...

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Robertson Products consist of: Lead Encasing Presses for Rods, Wire, Electric Cables and Rubber Hose. Extrusion Presses for Lead Pipe, Solder, Traps, Lead Wire, and Non-ferrous Alloys. Also, High Pressure Pumps, Hydro-Pneumatic Accumulators, Lead Melting Furnaces and Pots, Dies, Cores, etc.

John ROBERTSON CO. INC. Pioneers-Since 1858

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—the sure preventive of joint leakage and destruction

SMOOTH-ON No. 3 applied to gaskets or threads is virtually equal to solid metal in *permanent* pressure tightness—because the iron filling it deposits in every void or rough spot *reinforces* the gasket material or threads, and cannot shrivel, shrink, dry, crack or blow out.

Buy in 1 or 5-lb. can or larger keg from your supply house or if necessary from us direct.

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Estimates
Operation
Layout
Research
Management
Testing
Drainage
Fuels
Foundations
Electronics
Specifications
Production
Chemical Works
Chemistry
Combustion
Dams
Heating and Ventilating
Hydro-electric Developments
Industrial Buildings
Industrial Relations
Materials Handling
Metallurgy
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FOR ALL LIQUID PETROLEUM PRODUCTS
OIL METERS
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NRA MEMBER U.S. WE DO OUR PART

Empire Meters are accurate and it is easy to keep them accurate. They operate successfully through a wide range of temperatures and pressures and under most trying conditions. Empire Meters are known everywhere for long, dependable service and low cost of upkeep.

NATIONAL METER COMPANY

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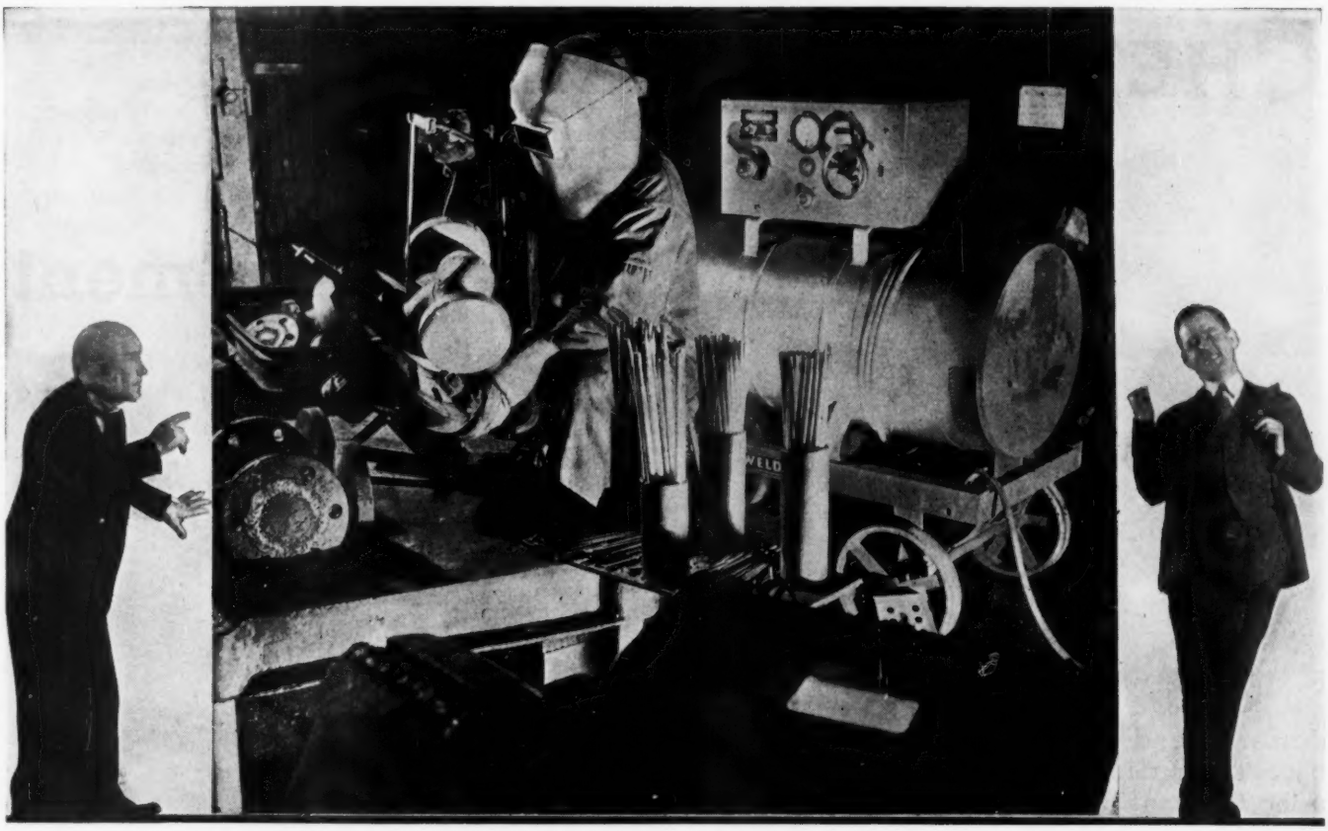
SHIELDED ARC WELDING IMPROVES EDWARD VALVES . . .



"Here, Lad, is where they fuse extra quality, extra strength and extra safety into Edward valves. It's done by welding with a shielded arc.

"They tell me that thousands of Edward valves of various types have been produced by this process. Especially forged steel valves. Under extreme service conditions, they stood up successfully."

What's NEW in Welding!

PROCEDURE HAND BOOK OF ARC WELDING DESIGN AND PRACTICE

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"Of course Edward valves stand up. They're using Lincoln *'Shield-Arc'* welders and that means a uniform welding current and high capacity. Those are two of the essentials of production line welding.

"The *'Shield-Arc'* provides all the other essentials too. That's why the super likes it as well as the welder operator. And why the cost accountant likes it as well as the super.

"For the same reason Lincoln is able to make this 3-way guarantee:

1. More weld metal deposit per K. W. H.
2. Faster welding per K. W. H.
3. Lower cost per unit of welding—the unit being per lineal foot of weld, or per pound of weld metal, or per hour of welding.

"Whether it's valves or jigs, machine tools or pipe, you can take *'Fleetweld'* electrodes and a *'Shield-Arc'* welder and have a pair that says 'We do our part.' Proof is yours for the asking."

LINCOLN

THE LINCOLN ELECTRIC COMPANY, CLEVELAND, OHIO

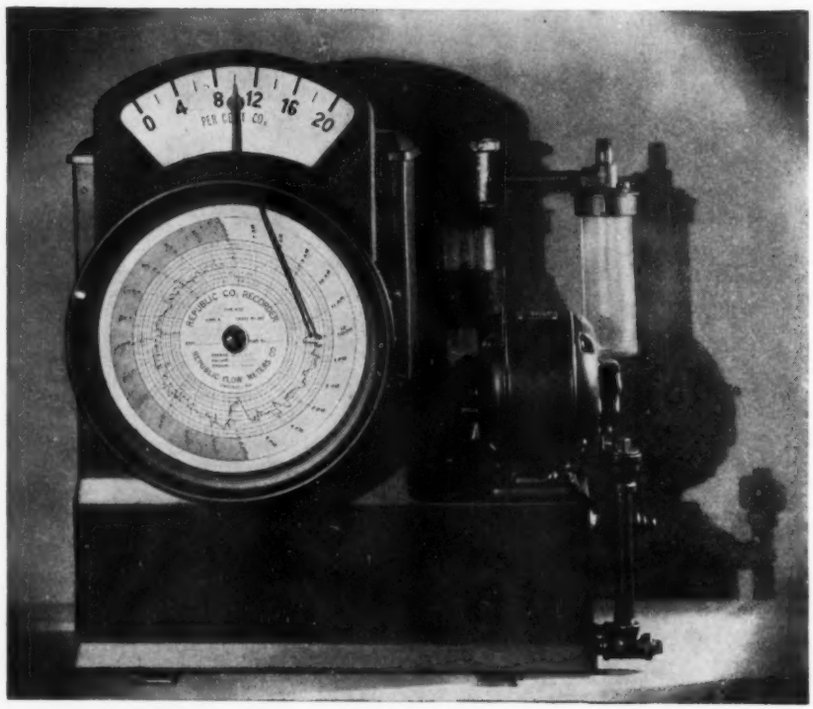
Largest Manufacturers of Arc Welding Equipment in the World

W-56

CHEMICAL ANALYSIS

The Basis for

All CO_2 Measurement



CO_2 measurement by Chemical Analysis is the fundamental and accepted standard against which all other methods of measuring CO_2 must be checked. This is clearly proved by the universal use of the well known Orsat apparatus as a check on CO_2 meters regardless of principle of operation. The frequency with which tests should be made and the length of time required to make a test with an Orsat makes it impractical for use in daily boiler operation.

For this reason Republic has spent eight years perfecting a Chemical CO_2 meter eliminating all sources of trouble such as glass tubing and other fragile parts found in the original meters of this type. The Republic Motor Driven CO_2 meter is an automatic Orsat built for continuous service under the most severe boiler room demands. It measures CO_2 directly and not inferentially and is therefore independent of such conditions as voltage, humidity, temperature, stack draft, gas velocity or atmospheric pressure. It provides a continuous pen line record of the CO_2 percentage, measured according to the Chemical method. The Republic Motor Driven CO_2 meter thereby guarantees an accuracy comparable only with that of an Orsat with the added advantage of a continuous written record, so necessary for efficient boiler operation and low operating cost. **Write for Bulletin No. 401.**

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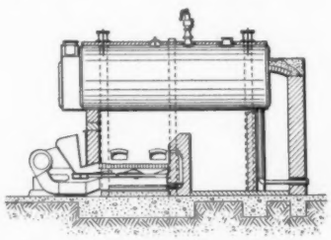
Executive Offices and Plant: 2232 Diversey Parkway, Chicago, Illinois

REPUBLIC

CO_2 METERS

Small Boiler Units as well as Large

The relative size of these two units is accurately shown, both drawings having been made on the same scale. The extreme range of Combustion Engineering installations of steam generating equipment is manifested by the fact that there are in operation today C-E boilers which have ten times the capacity of the *larger* boiler here illustrated.

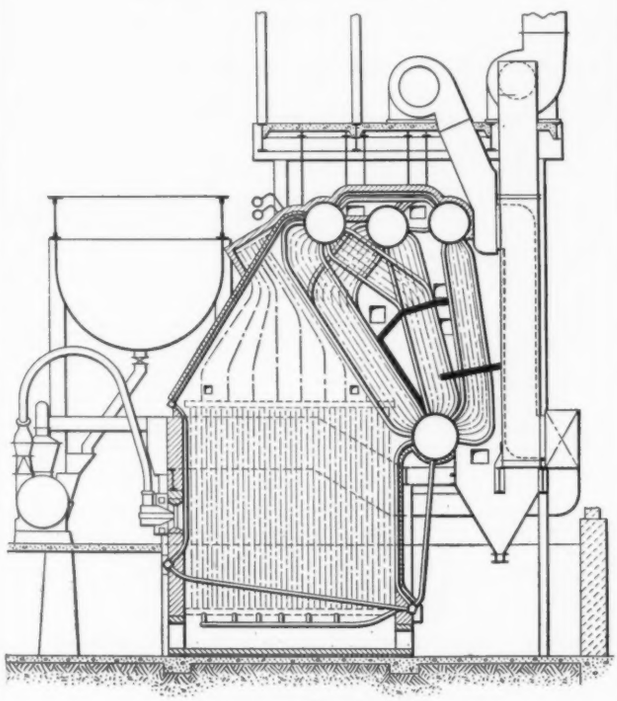


C-E CONTRACT

includes boiler and firing equipment as follows:
C-E H.R.T. Boiler
1500 sq. ft. of heating surface
Type E Stoker
(Electric drive type)

OPERATING DETAILS

CAPACITY, maximum continuous: 7200 lb. of steam per hour. (equivalent to 150 per cent of boiler rating.)
PRESSURE: 150 lb. per square inch
EFFICIENCY, Boiler and Furnace: 72 per cent.



C-E CONTRACT

covers complete boiler, firing and auxiliary equipment, as follows:
C-E Multiple Circulation Boiler 15,000 sq. ft. of heating surface
C-E Water Cooled Furnace
C-E Air Preheater
C-E Direct Fired System
for pulverized fuel firing comprising four Type R Burners and two Raymond Impact Mills each having a capacity of 10,000 lb. per hr.
Contract also includes
superheater, soot blowers and forced and induced draft fans

OPERATING DETAILS

CAPACITY, maximum continuous: 150,000 lb. of steam per hr.
OPERATING PRESSURE: 410 lb. per sq. in.
EFFICIENCY, Boiler and Furnace: 87 per cent.

Every C-E job—large or small—comprises equipment and overall design which extensive and diversified experience indicate to be best suited to the conditions.

The two drawings here reproduced show boiler units covered by two new contracts both of which were received by us on the same day. One has a capacity of 7200 lb. of steam per hr., the other 150,000 lb. per hr. Widely different in design and equipment detail, these two installations typify the range and diversity of Combustion Engineering work.

Small manufacturing plants, as well as the largest industrials and utilities, recognize the precise suitability of C-E equipment for their respective needs.

They know the value of dealing with an organization accustomed to developing designs for the most varied requirements, and which builds a line of equipment that provides complete freedom of choice.

They know, too, that every C-E job—large or small—reflects this Company's purpose: to make every C-E installation measure up to the requirements of a reference plant; an installation that will, through many years of operation, exemplify the practical advantages of Combustion Engineering's diversified experience with fuels and their use for the purpose of steam production.

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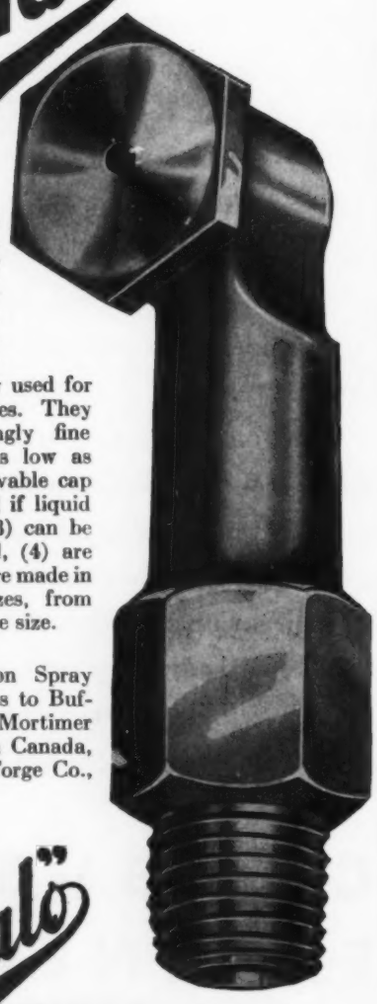
In modern buildings clean air is not a luxury—it is an asset. The tremendously increased interest in air conditioning indicates that within a very few years NO buildings will be modern without it. Because Buffalo Air Washers supply CLEAN, properly tempered air 365 days a year, at a very moderate operating cost, because they operate for a lifetime—because they are already in use in almost every type of structure in every branch of Industry, they merit your first consideration when you think of air-conditioning apparatus. Before you purchase or specify any air cleaning equipment—get all the facts about

"Buffalo" AIR WASHERS



The illustration shows a Buffalo Non-Clogging Spray Nozzle of the type used in Buffalo Air Washers. In addition to this service, Buffalo Spray Nozzles are commonly used for many industrial purposes. They (1) give an exceedingly fine spray on pressures as low as 15 lbs., (2) have removable cap which can be renewed if liquid handled is corrosive, (3) can be made of any material, (4) are non-clogging and (5) are made in complete line of sizes, from ¼ inch to 2½ inch pipe size.

Write for bulletins on Spray Nozzles or Air Washers to Buffalo Forge Co., 148 Mortimer St., Buffalo, N. Y., in Canada, Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

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PRICED RIGHT

You get more than you expect of a standard centrifugal pump when you order a Taber. Changeable Impellers is one of the extra values.

Your request for quotation will show you our price is right. What are your needs? Write us, requesting comprehensive Bulletin G-631.

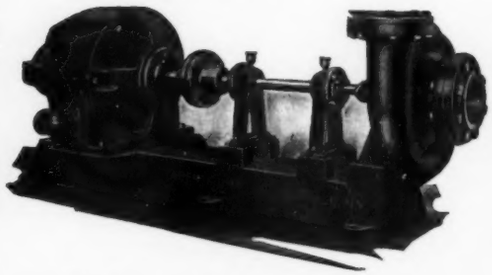

Fig. 603-G. Impeller is kept in true position. Stuffing Box is four shaft diameters deep. An extra value pump.

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If you desire capital or have it to invest; if you have a patent for sale or development; if you have on hand used machinery for disposal, or if you want such equipment; if you have copies of publications, or a set of drawing instruments to dispose of; if you need help or want a position, in fact, anything to be offered that somebody else may want, or anything wanted that somebody else may have—*use a classified advertisement in the Opportunities Section.*

RATES

Classified advertisements under this heading in MECHANICAL ENGINEERING are inserted at the rate of 60 cents a line, 50 cents a line to members of A.S.M.E. Seven words to the line average. A box number address counts as one line. Minimum insertion charge, 5 line basis; maximum 20 lines. Display matter carried in single column units of multiples of one inch at the flat rate of $10 per inch per insertion. Copy must be in hand not later than the 10th of the month preceding date of publication.

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29 West 39th Street, New York, N. Y.

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BUT WITH CORRECT LUBRICATION, YOU CAN CUT MAJOR PLANT COSTS

WITHOUT ADDITIONAL INVESTMENT

Complete line of lubricants . . . products of Socony-Vacuum member companies . . . can help you cut major plant costs today

Known World-wide for six decades as refiners a

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for 1934 a complete line newly d

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TRUE, lubrication is an insignificant cost, probably less than 1% of your total costs of conversion. But, today more than ever, it is dangerous to judge the importance of lubrication by its cost. During 1933, for instance, Gargoyle Lubricants helped a paper mill cut its power bill $2700. A copper mine reduced its maintenance and repair expense $1750. Scores of plants found that Gargoyle Lubricants insured uninterrupted production schedules. Plants in every industry found that correct lubrication produced savings *amounting to many times the annual cost of oil.*

Only this complete line of lubricants can meet all of 1934's demands

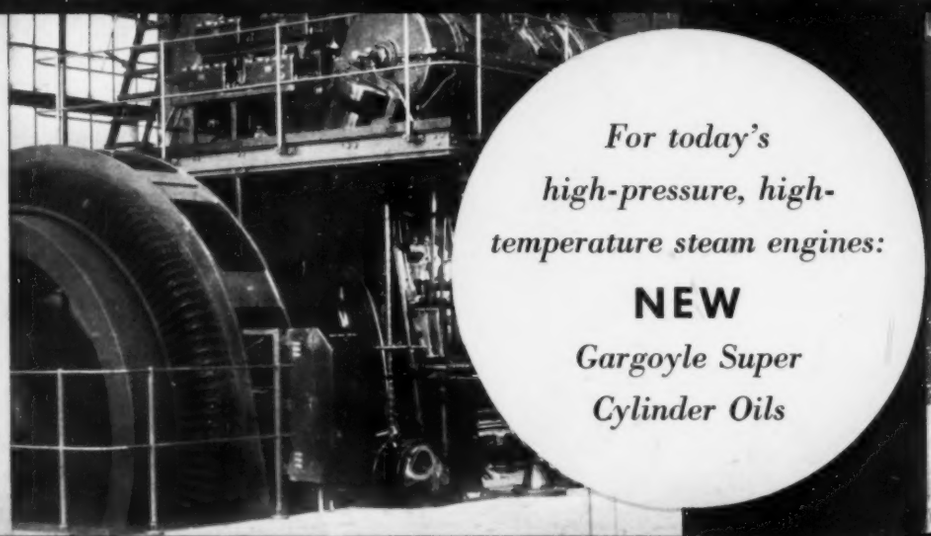
During the past two years, machinery builders, aiming for lower costs, have made many changes in design. Pressures, temperatures and speeds, for instance, have all been stepped up. Lubricants once adequate are today out-of-date. But Socony-Vacuum Corporation, always in close touch with machinery builders, has kept ahead of these developments, and offers you a complete line of lubricants specially designed to meet today's changed conditions—today's cost-cutting needs.

This watch manufacturer uses Socony-Vacuum Lubrication for all equipment from prime movers to watch-makers' lathes.

When you use Socony-Vacuum Lubrication Service, you are *sure* you're getting lubricants made to minimize *today's* costs. *Socony-Vacuum provides correct lubricants to meet every conceivable operating condition in every known type of machinery.*

SOCONY-VACUUM CORPORATION

New developments in Industry called for these NEW Lubricants



For today's high-pressure, high-temperature steam engines:

NEW

Gargoyle Super Cylinder Oils

and marketers of Industrial Lubricants—

Companies now announce designed to cut today's costs old and new

These lubricants are made—not for a price—but to help you lower today's plant costs

Thousands of industrial plants have found that the use of high-grade Gargoyle Lubricants pays for itself many times over. But, if you have some equipment that can operate *just as economically* on lower-priced lubricants, Socony-Vacuum will recommend and supply those lubricants. Socony-Vacuum, with a complete range of products, *sells you the lubricants that will do the most efficient, most economical job for you.*

Socony-Vacuum sells this manufacturer lubricants for 25¢ . . . and $1.42 a gallon.

This service costs you nothing, but may help you lower your unit production costs

Today—now—in thousands of plants throughout the world, Socony-Vacuum lubricating engineers are working closely with plant executives. They are studying equipment and operating conditions. They are developing more efficient methods of oil application. They are recommending simplified methods of oil storage and inventory. With their background of experience in wide variety of plants, they are, in many cases, suggesting ways of improving general plant operations.

Socony-Vacuum Engineering Service, by recommending improved methods of oil application, saves machinery manufacturer $1800 a year in bearing renewals.

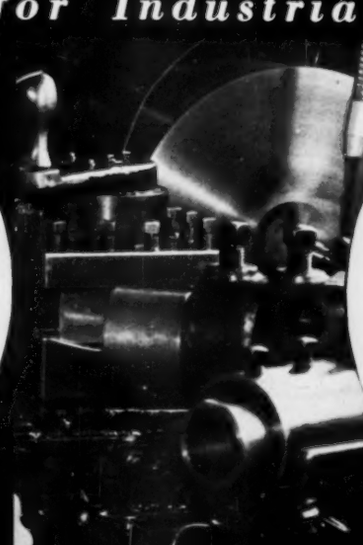
Socony-Vacuum Engineering Service brings you the latest world-wide developments in engine design and lubrication. Whatever new lubrication problem confronts you, it is more than likely that Socony-Vacuum engineers have met and solved this problem somewhere else in the world.

World Headquarters for Industrial Lubrication

For bearing pressures of many thousand pounds to the square inch:

NEW

Gargoyle Greases



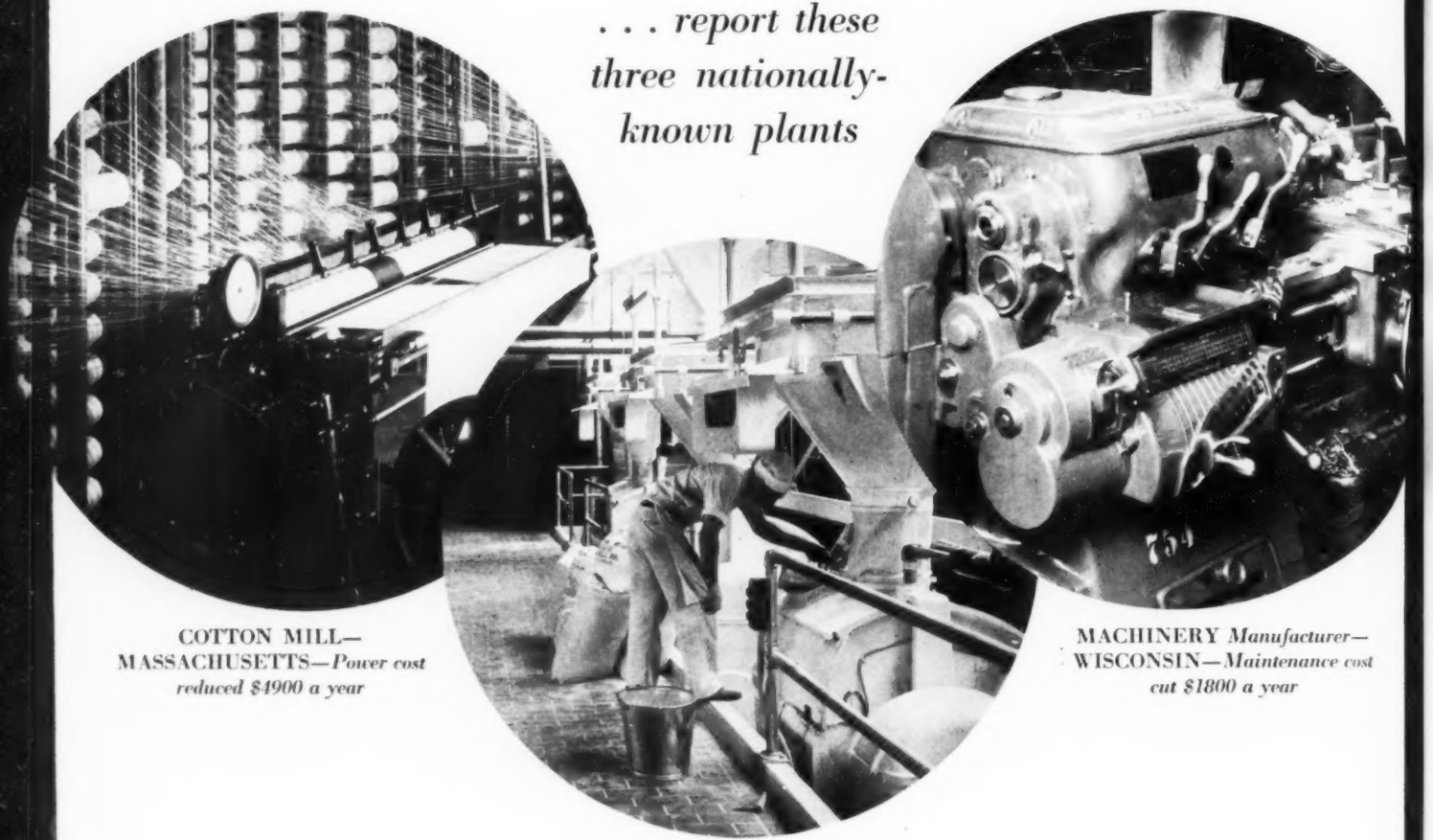
For new types of cutting tools— new types of materials:

NEW

Socony-Vacuum Cutting and Soluble Oils

"It paid well to put Socony-Vacuum Lubrication on our cost-cutting program"

. . . report these three nationally-known plants



COTTON MILL—MASSACHUSETTS—*Power cost reduced $4900 a year*

MACHINERY *Manufacturer*—WISCONSIN—*Maintenance cost cut $1800 a year*

FOOD PRODUCTS MANUFACTURER—MINNESOTA—*Power cost cut $5400*

Today it will pay you, too, to consider correct lubrication as a source of substantial production cost savings.

Leading plants in every industry have found, for instance, that Socony-Vacuum Lubrication, by reducing frictional losses, has cut their power bills anywhere from 3% to 10%. A 3% power saving in your plant would more than likely pay your total oil bill for the entire year.

Others have found that Socony-Vacuum Lubrication, by minimizing wear, has reduced maintenance and repair expense thousands of dollars annually.

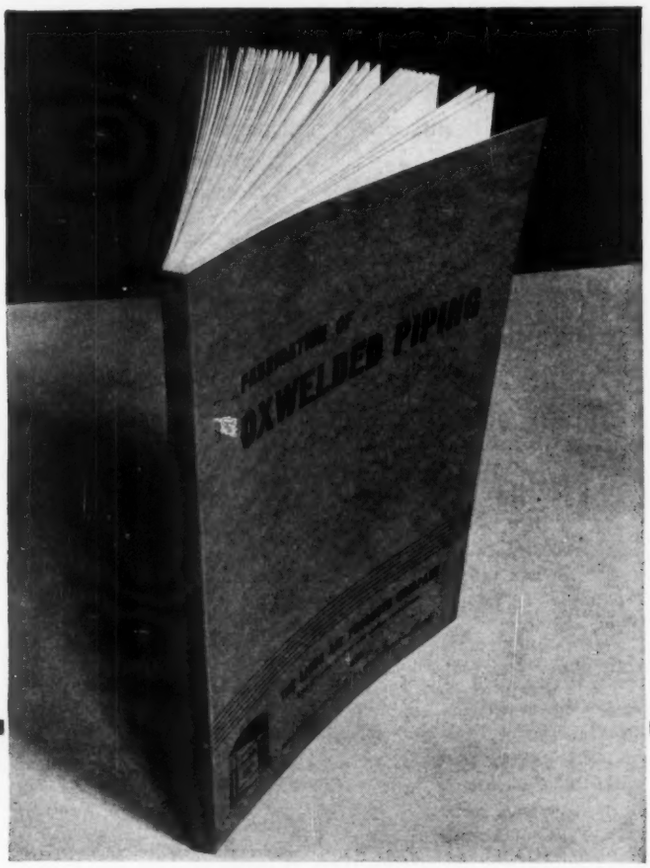
Do you have operating problems such as excessive rejects? Would you like to find some way to avoid frequent cleaning of deposits from pistons and valves? Or some sound method of speeding up production schedules? Socony-Vacuum Lubrication is helping to solve such problems daily in leading plants in every industry. It may pay you well to ask a representative of any of the companies listed below to show you important lower-cost records made in plants operating equipment similar to your own.

Socony-Vacuum Corporation, 26 Broadway, New York City. Branches and distributors throughout the world.

GARGOYLE Lubricating Oils

SOCONY-VACUUM CORPORATION

MEMBER COMPANIES: Standard Oil Company of New York, Inc. • White Star Refining Company
Magnolia Petroleum Company • White Eagle Oil Corporation • Vacuum Oil Company, Inc.
Lubrite Refining Corporation • Wadhams Oil Company



THIS NEW BOOK-

covers all phases of Oxwelded Piping

HERE is the only complete presentation of the fundamentals of pipe welding technique ever published. This new 160 page book, "Fabrication of Oxwelded Piping" answers every question on the installation, fabrication and erection of oxwelded piping systems. It contains complete data and procedures for using recently developed welding methods, new material on welding fittings and the welding of joints in steel, cast iron and non-ferrous piping.

Engineers, inspectors, superintendents, foremen, pipe fitters and welders will find this book a mine of general and specialized information. From the standpoint of management charged with making capital expenditures, it points the way to lowered welding costs through its presentation of detailed procedures on Lindewelding. The growing use of this new method in the field of industrial and building piping makes it imperative that up-to-date builders, contractors, architects and engineers study this technique, presented for the first time in the "Fabrication of Oxwelded Piping."

We will gladly send you "Fabrication of Oxwelded Piping" free of charge, if you can use it to advantage. It is offered only to those who write for it. Address your request to the nearest Linde District Office.

LIVE TOPICS DISCUSSED IN THIS BOOK

●

—fundamentals of pipe welding technique. The clear, concise presentation will enable an operator to learn pipe welding more readily and equip him to handle any unusual welding problem.

—procedures on Lindewelding, covering the application of this technique to all classes of piping.

—time and material data with tables for estimating costs provide essential information for use as a basis for computing costs.

—layout and fabrication of oxwelded piping, establishing reference lines, laying out cuts with or without the use of templets, header fabrication etc.

—special recommendations on joint design and the latest practices in oxwelding cast iron, copper, brass and lead pipe.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

IN CANADA, DOMINION OXYGEN COMPANY, LTD, TORONTO

District Offices

Atlanta	Chicago	Houston	Milwaukee	St. Louis	
Baltimore	Cleveland	Indianapolis	Minneapolis	Salt Lake City	
Birmingham	Denver	Kansas City	New York	San Francisco	
Boston	Detroit	Los Angeles	Philadelphia	Seattle	
Buffalo	El Paso		Pittsburgh	Tulsa	

ANNOUNCEMENT

THE current (1933-34) MECHANICAL CATALOG successfully introduced half pages. These will be continued since this size space unit is of value to the small manufacturer. The full page and multiples thereof are available, as usual, for the larger manufacturer having a variety of items and therefore requiring more space for an "abridged catalog" of his line.

Product listings form an essential part of a properly organized reference service and when correct they constitute an invaluable source of information. Therefore, listings are accepted from concerns who desire this form of contact—a *nominal* charge being made for each listing under a specific product heading.

Concerns whose descriptive data appear are entitled to free listing with inclusion of trade names upon the basis specified in the rate card reproduced below.

New York, N.Y. — **MECHANICAL CATALOG** — **Annual**

Rate Card No. 7
Issued December 6, 1933
In effect December 6, 1933

1.—GENERAL ADVERTISING

Rates represent the space cost for one year.

a. Catalog of half (½) page..... $110
Catalog of one (1) page..... 200
Catalog of one and a half (1½) pages 280
Catalog of two (2) pages..... 360
Catalog of two and a half (2½) pages 430
Catalog of three (3) pages..... 500
Rate for additional half pages $50 each

Advertisers are allowed free listing with inclusion of trade names in "Index to Manufacturers" upon the following basis:

1. Ten listings with each half page used.
2. Twenty listings with each full page used.

Additional listings will be charged for at $1.00 each.

Names of advertisers will be identified as such by means of an appropriate mark and page number reference with each listing.

b. COVERS, COLORS AND INSERTS (Not sold)

c. POSITION

Catalogs are arranged in alphabetical order subject to some variation due to makeup.

d. EQUIPMENT CATALOGED

Power Plant Equipment.

Measuring and Testing Apparatus.

Power Transmission Machinery.

Materials Handling Equipment.

Metals, Alloys and Other Materials.

Foundry, Rolling Mill and Forge Equipment.

Metal Working Machinery, Machine Tools and Shop Equipment.

Compressors, Blowers and Pumps.

Heating and Ventilating Equipment, Refrigerating Machinery.

Specific Industry Machinery, General Industrial Equipment.

Electric Motors and Control.

e. CONTRACT REQUIREMENTS

All copy must conform to established typographical style. Instruction sheet supplied upon request.

f. Minimum size of advertisements—half page.

g. Contracts not subject to cancellation.

h. 10% of the space charge is to be paid upon reservation and balance upon publication.

2.—CLASSIFICATIONS—INDEX LISTINGS

a. Charge to non-advertisers for listings in "Index to Manufacturers of Industrial Equipment, Materials and Supplies" under specific product heading is $1.00 for each listing of name and address. Limited to two lines.

3.—READING NOTICES (Not accepted)

4.—COMMISSION AND CASH DISCOUNT

a. Agency commission O per cent.
b. Cash discounts 2% and 5%
c. 2% discount allowed for payment within 10 days. 5% discount for advance payment 6 months before date of issue.

5.—MECHANICAL REQUIREMENTS

a. Size of Cuts: Width up to 3¾" allowed. Consult publisher regarding cuts exceeding that dimension.

b. Depth of column 10 inches.

c. Two columns to a page.

d. No two-page spread, but facing pages are acceptable.

e. Page, type space, 10 in. deep x 7 in. wide.

f. Half page, type space, 10 in. deep x 3⅜ in. wide.

See items 1*d* and 1*e*.

f. Closing Date—Last forms close about July 1st.

g. Halftone Screen—120.

h. Cuts made by us charged at cost.

6.—CIRCULATION

	Date of Statement	*For*	*Circulation*
a. Not a member of A.B.C.			
b. Character of circulation; mechanical engineers and engineer-executives.	December 1, 1933	1933-34 Edition	16,000 (Gross)
c. Locality of circulation: national, largely in industrial centres.	.....	.....	.....
d. In circulation during October.	.....	.....	.....

7.—MISCELLANEOUS

a. Advertising subject to approval.

b. Established 1912.

c. Controlled free distribution to engineers responsible for buying.

d. Also publish MECHANICAL ENGINEERING (monthly).

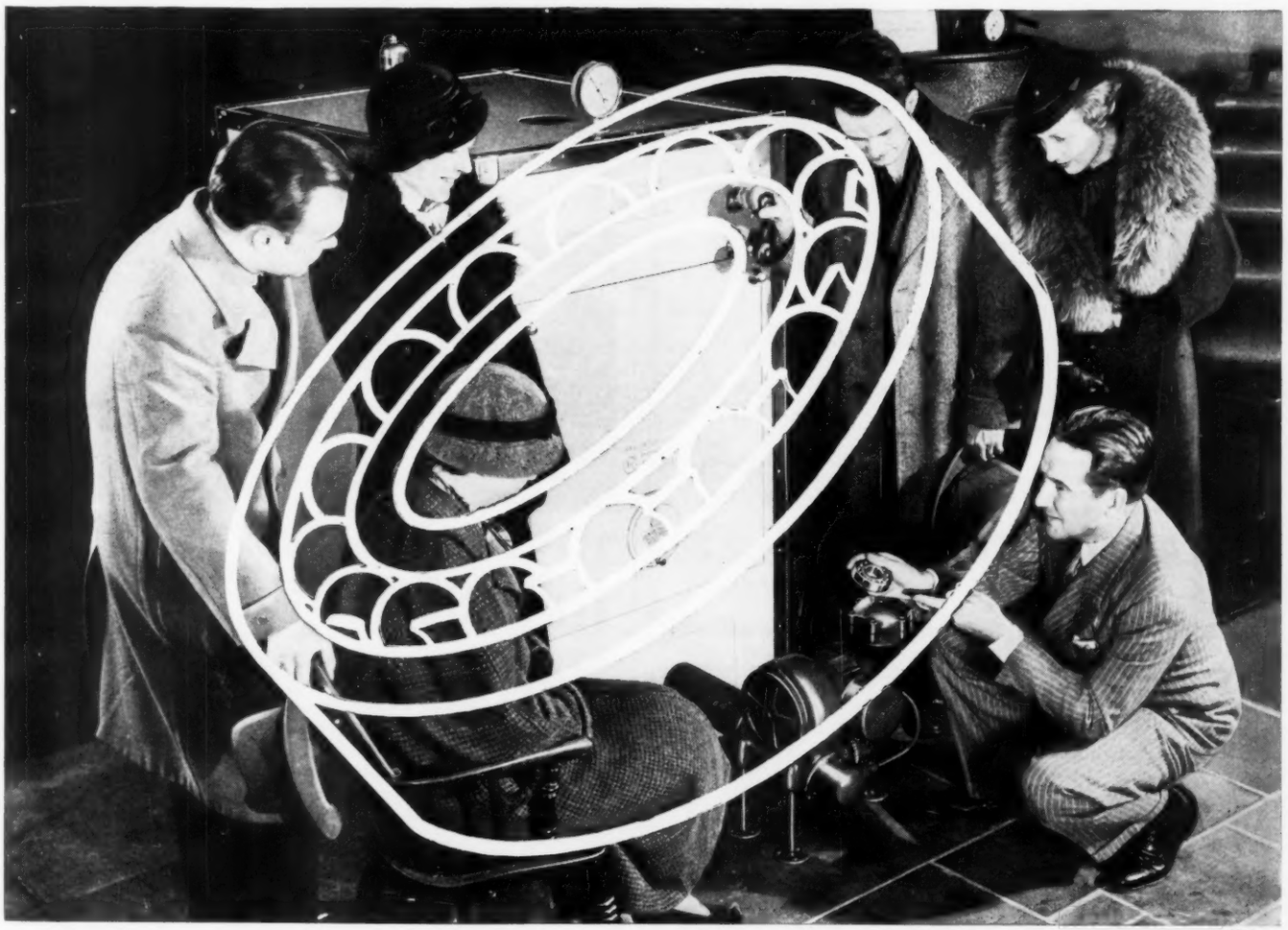
e. Publishers:
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
29 West 39th Street, New York, N. Y.

(Prepared in conformity with "Standard Rate Card" of American Association of Advertising Agencies)

Booklet on MECHANICAL CATALOG describing abridged catalogs and listings, also filing copy of Rate Card may be had upon request.

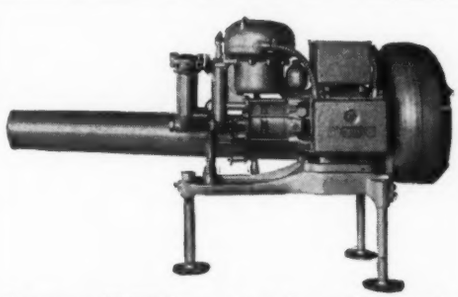
THE AMERICAN SOCIETY of MECHANICAL ENGINEERS, 29 W. 39th St., New York.

Bearing on SALES



8140

For example: The Williams Oil-O-Matic



For ten years SKF Bearings have given unfailing service in Williams Oil-O-Matic Burners...and depend upon it, their recognized performance standards have helped Oil-O-Matic sales, too.

SKF

BALL AND ROLLER BEARINGS

PEOPLE are not only *buying* more today. They are *thinking* more about *what* they're buying.

The manufacturer, therefore, who equips with cheap bearings faces a double hazard. He is not only taking a chance on performance, he is taking a chance on sales!

Buyers know the significance of the phrase "SKF Equipped." They know that the symbol SKF stands for the finest bearings that the world's foremost bearing organization can produce.

SKF is not the cheapest bearing in the world to buy... not by a long shot. But depend upon it from every point of view ...performance, service, maintenance, good will and sales... it's the cheapest bearing in the world to use. When you buy, or when you manufacture, anything that turns on bearings make sure that the bearings are SKF.

SKF INDUSTRIES, INC., Front St. & Erie Ave., Phila., Pa.

POSITION WANTED

—but not a C.W.A. Berth

Several months of unemployment forced me to seek refuge under the wings of paternal and benevolent C.W.A.

I possess enough strength of will to continue seeking employment with a progressive organization, where ability, initiative, a forceful personality, the will to work hard and to carry responsibility are considered of paramount importance.

EXPERIENCE: Rather unusual and diversified, covering: Sugar mill and refinery machinery; Power plant equipment and heat transfer apparatus;
Chemical and materials handling equipment, industrial filters;
Labor savings devices and methods;
Cost accounting and cost analysis;
Appraisal and patent work;
Industrial reporting;
Research on mechanical, electrical and labor problems.

EDUCATION: Graduated from a prominent engineering University (M.A. in M.E.); speak several foreign languages fluently.

Am in possession of successful record, covering such functions as operating, research and development engineer, as a personal assistant to an executive and as a chief engineer with well-known companies.

Address: Box M.E.-870
Care of "MECHANICAL ENGINEERING"

J&L
JONES & LAMSON

Hartness Flat Turret Lathe
Fry Automatic Lathe
Hartness Automatic Die
Hartness Comparator
Flanders Ground Tap
Hartometer Screw Thread Gage

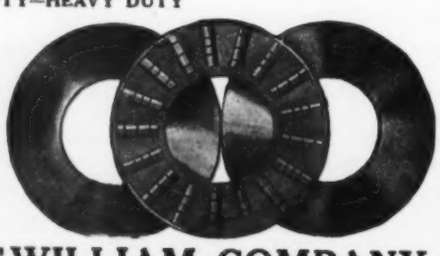
JONES & LAMSON MACHINE CO.
SPRINGFIELD, VERMONT

BALL AND ROLLER
BEARINGS
LIGHT DUTY—HEAVY DUTY

Catalog Upon Request

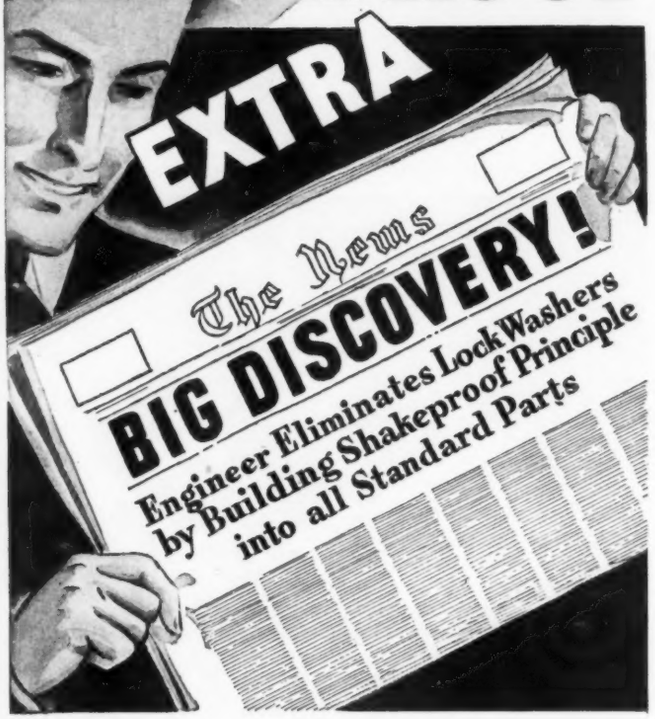
Ball Thrust Bearings
Roller Thrust Bearings
Journal Roller Bearings

Special Bearings to Order



THE GWILLIAM COMPANY
360 Furman Street, BROOKLYN, N. Y.

SHAKEPROOF


EXTRA
The News
BIG DISCOVERY!
Engineer Eliminates Lock Washers by Building Shakeproof Principle into all Standard Parts

Improve your product *this money-Saving way*

HERE'S an idea that deserves the attention of every designing engineer. The adaptability of the Shakeproof principle makes it possible to build this positive locking method right into any standard part. This means you have the powerful twisted teeth of Shakeproof biting into both work and nut surfaces and, at the same time, no separate lock washers are required. Thus you are providing the greatest possible protection against vibration and also saving time and money on the production line. Let us show you how this new idea can be applied to your product—write for complete information today!

Send today for your free copy of this complete Shakeproof Catalog. Explains thoroughly the many advantages that Shakeproof offers—also shows new patented Shakeproof products.

SHAKEPROOF *Lock Washer Company*

{Division of Illinois Tool Works}
2511 N. Keeler Ave. Chicago, Ill.

Type 12. Internal
Type 11. External
Type 15. Countersunk
Type 20. Locking Terminals
U. S. Pat. 1,410,554—1,604,122—1,686,651—1,782,367—Other Pat. Pending—Foreign Pat.

An Unusual Alloy—

CRAMP'S SUPERSTRENGTH BRONZE

Physical Characteristics

GRADE A	GRADE B	TENSION	GRADE C	GRADE D
		Ultimate tensile strength, lbs. per sq. in.		
115,000	110,000	Sand Cast	100,000	90,000
118,000	115,000	Forged or Rolled	105,500	93,000
		Yield Point in tension lbs. per sq. in.		
68,000	63,000	Sand Cast	55,000	45,000
70,000	65,000	Forged or Rolled	60,000	50,000
		Proportional Limit		
32,500	29,500	Sand Cast	25,000	20,000
		% Elongation in 2"		
10	15	Sand Cast	20	25
8	15	Forged or Rolled	18	20
		% Reduction in Area		
10	15	Sand Cast	18	20
8	15	Forged or Rolled	18	20

A folder descriptive of this unusual alloy will be forwarded upon request.

CRAMP BRASS AND IRON FOUNDRIES COMPANY
PASCHALL STATION PHILADELPHIA, PA.

January, 1934 MECHANICAL ENGINEERING Vol. 56, No. 1
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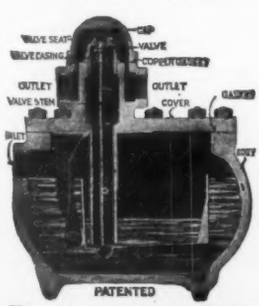
THE GENUINE *Squires* STEAM TRAP



gives the utmost in service on steam, air or gasoline.

May we send Catalog H-9 giving complete information?

The C. E. SQUIRES CO., Cleveland, O.

"THESE BW PRINTS HIT ME RIGHT!"

. . . "They're far easier to read and to check. Pen or pencil notes show up clearly on the white background. And we can get BW Prints as quickly and as easily as blue prints."

Bruning BW Prints are Black And White Positives—made *without the use of a negative*. Your Bruning dealer can supply them, or you can produce them in your own blue printing department with a simple, inexpensive BW Developing Machine.

Investigate BW Prints. Write us for complete information.

The BW Process, Paper and Cloth are protected by U. S. Patents No. 1821281 and No. 1841653. The BW Machines, U. S. Patent No. 1891722, are for exclusive use with the BW Process.

Charles Bruning Company, Inc.
Since 1899

Home Office
102 Reade Street
New York City

Chicago Office
445 Plymouth Court
Chicago

Boston Detroit Los Angeles Newark
Pittsburgh San Francisco St. Louis

BRUNING

THE NEW STANDARD

Thin Wall

MAIN BEARING and CONNECTING ROD LINERS

FLEXIBLE - LIGHT WEIGHT - BABBITT LINED
STEEL BACKED - ACCURATE - DEPENDABLE - ECONOMICAL

For Extremely HEAVY DUTY
Thin Wall **Steel Backed Bearings *Lined with LEADED COPPER***
(Trade Name "Clevite")

THE CLEVELAND GRAPHITE BRONZE CO., Cleveland, Ohio

Originators of THIN WALL Bearings

EFFICIENT!

SPEED REDUCTION

COMPACT UNITIZED
EFFICIENT POWERFUL
ECONOMICAL ENDURING

MEMBER OF AGMA

Send for Catalog

BOSTON GEAR WORKS, INC.
DEPT. ME, NORTH QUINCY, MASS.
BOSTON NEW YORK PHILADELPHIA
CLEVELAND CHICAGO

Service Stations from Coast to Coast

BOSTON GEARS

Specific, dependable information on—

electrical measuring instruments and testing apparatus, and on their use in testing mechanical and electrical equipment

—is now available to industry

through the completion of

ELECTRICAL MEASUREMENTS

Formulated by the Committee on Instruments and Apparatus of the ASME Committee on Power Test Codes, this report is intended to define standard methods for the electrical measurements required by the various test codes which have been developed for prime movers and other auxiliary equipment.

In addition to material on instrument transformers, load rheostats, input of motors and output of generators, the report covers voltage, current, power, energy, resistance, frequency, and power factor measurements.

ELECTRICAL MEASUREMENTS will be published in March. The price will be $1.25, but ASME members who place orders in advance of publication may obtain copies at $1.00 each.

Orders with remittance should be sent to

Publication-Sales Department
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 West 39th Street, New York, N. Y.

USS PLYKROME

can be fabricated, welded, drawn, spun, beaded, formed, and cold rolled without special equipment

Plykrome will not separate or split under severe forming operations

THE unique method of bonding stainless steel to the carbon steel backing effectually prevents any splitting or separation under severe forming operations with standard equipment.

Hence Plykrome offers an economical and dependable solution to the problem of combating corrosion and contamination at low cost. Plykrome presents a solid surface of standard USS 18-8 stainless steel, but it relies upon low cost carbon steel for necessary physical strength.

Complete metallurgical information and guidance in the use or working of Plykrome may be had upon request.

Illinois Steel Company

208 S. LA SALLE STREET CHICAGO ILLINOIS

SUBSIDIARY OF UNITED STATES STEEL CORPORATION

U S S CHROMIUM-NICKEL ALLOY STEELS ARE PRODUCED UNDER LICENSES OF THE CHEMICAL FOUNDATION, INC., NEW YORK, AND FRIED. KRUPP A. G. OF GERMANY

A Word About Firms *who have abridged catalogs* in the 1933-34 MECHANICAL CATALOG

(No. 5 of a series)

Skinner Engine Co., Erie, Penna. Founded in 1868, this company has one of the largest plants in this country devoted exclusively to the building of steam engines. The Skinner "Universal Unaflow" was the first poppet-valve Unaflow engine manufactured in this country, and is built under more than fifty patents owned exclusively by this company. These engines are offered in sizes from 75 to 2000 horsepower. Many "Universal Unaflow" engines have been installed to replace purchased central station current, under the "Skinner Guaranteed Saving Contract," and have paid for their entire cost, including the cost of the generators, in the savings against rates as low as 1.1c per kilowatt hour.

Continental Valve & Equipment Co., Inc., Framingham, Mass. A Delaware Corporation was formed to succeed the Continental Valve & Equipment Co., an Illinois Corporation, through outright purchase, which company succeeded the Framingham Manufacturing Co. and the Leonard Machinery & Tool Co., formed during the early part of the World War in 1915 by Olaf E. Oleson, Vice President of the present company, and which companies were pioneers of the product now manufactured by this company. There were no forged steel fittings or forged steel unions made up to that time, and the founder of the above companies, being connected with the utility industry for a number of years, designed forged steel material—valves, fittings, and unions—for the purpose of meeting the approaching conditions of higher pressures and higher temperatures in central stations of the utility corporations and in the cracking processes in the oil fields.

Mears-Kane-Ofeldt, Inc., 1903–1915 E. Hagert St., Philadelphia, Penna. This company is one of the pioneer manufacturers of gas-fired steam boilers for process work. Since 1904 when William Kane built the first automatically controlled gas-steam boilers to bear his name, Kane boilers have been constantly improved and are still one of the leaders in their field. A companion boiler, the Ofeldt, is one of the fastest steaming boilers made. Agents in several large cities and local gas companies give wide distribution.

Chicago Tubing & Braiding Co., 229 N. Clinton St., Chicago, Ill. Manufacturers of Flexible Metallic Hose for more than thirty-one years. This concern has pioneered in introducing many different styles of Flexible Metal Tubing and has been instrumental in introducing its use for many commercial and industrial activities. Their leadership in this respect becomes an invitation to industrial engineers to consult with this company whenever their needs seem to indicate this kind of a product.

Cleveland Worm & Gear Co., 3263 East 80th St., Cleveland, Ohio. Organized in 1912—was one of the first companies to manufacture automotive worm gearing in commercial quantities. In 1916 the development of an efficient industrial worm gear drive led to the production of a complete standard line of worm gear speed reduction units which were placed on the market in 1919. Cleveland drives of all sizes have been remarkably successful because they are a combination of sound engineering, accurate workmanship, and intelligent application of the worm gear principle of power transmission. No other type of gearing is manufactured by Cleveland and Cleveland engineers devote their attention to this one product.

Gwilliam Co., 360 Furman St., Brooklyn, N. Y. Incorporated in 1912, by George T. Gwilliam, a pioneer in the Bearing Industry, who early recognized the need for a source of supply for "Hard to Get" and obsolete sizes and unusual types of bearings. Specializing in the design of these and with a set-up that permitted the production of various types and sizes of anti-friction bearings in quantities of "one to one thousand" and backed by careful engineering, the plan proved a success. Today many "standard" types and sizes of bearings are now produced and carried on hand for immediate delivery besides a large stock of "Specials." A similar line is carried in the Philadelphia office.

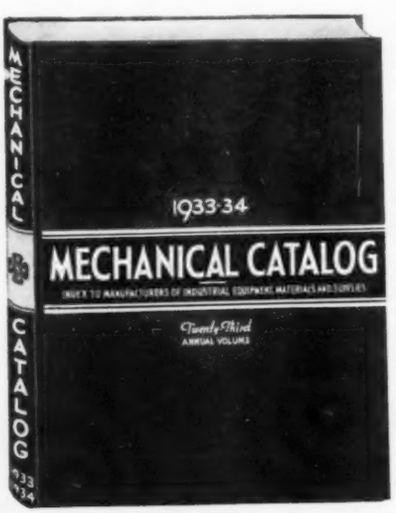
Chicago Pump Co., 2330 Wolfram St., Chicago, Ill. Established a quarter of a century ago, this company has earned a place foremost in the ranks of centrifugal pump manufacturers by honest manufacture of quality products. They strive to produce long-life pumps and pumping equipment that give the best service and results and to make easy the replacement of parts. Their products include the following: Sewage ejectors, bilge or sump pumps, electric cellar drainers, screw-feed sludge pumps, horizontal centrifugal pumps, hot or cold water and brine circulating pumps, vacuum heating pumps, condensation pumps, pneumatic water systems, "Automatic Alternator" for duplex pumps to transfer the operation from one pump to the other, aerators for aerating sewage, liquid sewage samplers, "Comminutor" or chopper screens, speed screens and water seal pumps.

Hydraulic Press Mfg. Co., Mount Gilead, Ohio. Fifty-seven years ago the first H-P-M Hydraulic Press was built. Since that time the company has pioneered many of the major modern developments that have been responsible for the advancement of hydraulic press performance. One of the most outstanding achievements in this direction is the H-P-M Hydro-Power Press . . . an economical and efficient production machine that combines hydraulic smoothness and flexibility with the desired speeds for production work. Today, this company is recognized as one of the largest exclusive Hydraulic Press builders in the world, with a corps of hydraulic engineers that are qualified through actual experience to work with a manufacturer faced with a production problem.

McDermott Water Heaters, Inc., 101 Park Ave., New York, N. Y. Manufacturers of heat exchangers for domestic water, oil and commercial processes. The first coil within a heating boiler known to New York City was installed by this company. This principle of circulating tank contents through the boiler enables all transfer surface to be used, and it has been epochal in water heating, being definitely the reverse of circulating boiler contents through tanks.

Schubert-Christy Corp'n, Affton, St. Louis County, Mo. For more than a score of years Schubert-Christy Cooling Towers have been serving industry in the cooling of water. They manufacture mill fabricated cooling towers in atmospheric, forced draft, induced draft and combination draft types. This company pioneered the modern type of induced draft cooling tower. Bakelite nozzles, and splash plates, copper nails, and heavily cadmium plated bolts are standard equipment. The present line of towers includes capacities from 10 G. P. M. to 40,000 G. P. M. and larger.

Shakeproof Lock Washer Co., 2561 North Keeler Ave., Chicago, Ill. Over ten years ago, when this company introduced its new patented twisted-tooth principle for the locking of nuts, bolts, screws, etc., it was the first lock washer that differed in its design from the old style spilt type. Its introduction required comparative tests with all other washers used and its quick acceptance by all types of industry proved that the Shakeproof principle was a definite contribution to industrial progress. Other products are the Shakeproof Tapping Screw and the Shakeproof Self-Locking Set Screw. If you have a locking problem, be sure to ask Shakeproof to send one of their skilled engineers to study your problem—this service is free and without obligation.



The only specialized reference annual for the buyer and specifier of mechanical equipment and engineering materials—contains the essential data of outstanding firms whose products are of interest to engineers and engineer-executives

Kraissl Co., Inc., 622 Main St., Hackensack, N. J. This business was founded in April, 1926, by Frederick Kraissl, Jr., as an engineering concern to represent manufacturers of allied engineering equipment. Particular emphasis was given to pumping machinery and the representation of the American Machine & Foundry Co. When this firm decided to withdraw from the pump industry, the Kraissl Company took over their patent rights and entered the manufacturing field. The particular mission of this business has been the searching out and solution of pump problems in specialized quantity markets. The basic theory has been that no one displacing mechanism will meet all requirements and the method of approach has been to employ the right design for each type of service. This has lead to the development of a number of new pumps, some of which have become sufficiently widely used to become standardized.

Bristol Co., Waterbury, Conn. Established in 1889 by William H. Bristol, pioneered the development of the original recording gauge and thermometer, which initiated industry's first attempt to control production. For the first time these early "Bristol" Recorders made it possible by means of continuous chart records to detect any and all variations of pressure or temperature from prescribed standards. They revealed these fluctuations in a form that could be analyzed, filed, and preserved for future reference. From 1889 to 1908 "Bristols" Instruments were manufactured in one small building. Today the "Bristol's" plant comprises a number of buildings, each equipped with the most modern facilities for turning out a quality product. Branch offices are maintained in principal cities throughout the country, in four of which complete facilities are available for reconditioning, recalibration, and repair work.

A. D. Granger Co., 13 Park Row, New York, N. Y. This company was established in 1893 and incorporated in 1900. A firm of contracting engineers, specializing in power plant machinery, including boilers, engines, electric generators, feed water heaters, pumps, steam turbines, cranes, chimneys, breechings, etc., including complete installations with piping and all accessories. Also oil conversion installations, including the oil storage, pumping, and heating units, as well as the remodeling of furnaces. The company represents several old established builders, including the Murray Iron Works of Burlington, Iowa, and also handles the Oswego internally fired water tube boiler exclusively.

St. Regis Paper Co., Oswego, N. Y. The parent company comprises organizations in all parts of this continent as well as a number of plants abroad. Lumbering is done in Quebec, the Adirondack section of New York, and in northern Vermont and New Hampshire. In upper New York State the company owns groundwood and sulphite pulp mills and a number of paper mills producing newsprint, groundwood book and rotogravure papers as well as specialties; also Kraft pulp and rope pulp and paper mills. A wide variety of heavy-duty paper sacks are manufactured and printed by subsidiaries in all parts of the country. At Oswego, an extensive machine shop operation produces automatic equipment for filling and closing paper bags, mainly serving the cement, lime, plaster, stucco, sugar, salt, flour milling, and chemical industries; the Cleveland Friction Clutch (Western Engineering & Manufacturing Division); Bates Wire Ties and Tools; and contract engineering and machine shop service.

Kingsbury Machine Works, Inc., 4326 Tackawanna St., Philadelphia, Penna. The principle of tapering oil films was first applied in this country to thrust bearings by Albert Kingsbury. One of the earliest commercial installations was made in 1912 in a hydro-electric unit at the Holtwood Station of the Pennsylvania Water & Power Co., on the Susquehanna River. The marked success of this bearing led to the adoption of Kingsbury Bearings for all ten units at that plant and to the rapid acceptance of Kingsbury Bearings among hydroelectric engineers. In similar manner the use of Kingsbury Bearings spread through the steam turbine field and then through the marine field; and they are now recognized as standard for those and similar duties. They are now available for heavy duty in all classes of machines.

Beneath every *real* pilot is a fine GROUND SCHOOL

YOUR standing as a pilot, a maintenance man, or an executive in modern aviation will depend on the quality of your basic training — what you learn about aviation *to begin with*, and the way you learn it.

Every regular Boeing student receives thorough ground training. His laboratories, shops and classrooms are the most complete in America. Back of each step in this part of his instruction is the combined research and construction knowledge of Boeing, Sikorsky, Vought and Stearman airplane companies, Hamilton Standard Propellor and Pratt & Whitney — affiliates of the Boeing School.

And in addition, he has daily observation, on the Oakland Airport, of the servicing and operation methods of United Air Lines — in flying its multi-motored mail-and-passenger planes on Coast-to-Coast and Coastwise schedules.

In *all* of its practices the Boeing School must constantly meet the requirements of the world's greatest flying and manufacturing group. Its instruction is keyed to a standard that cannot be relaxed.

Before you sign up with *any* school, satisfy yourself which one gives the training that will best qualify you for your career in Aeronautics. The current Boeing Bulletin has complete information — courses, costs, enrollment requirements, etc. For convenience, fill in and mail the coupon below for your copy. *Next Regular Enrollment, April 3.*

BOEING SCHOOL OF AERONAUTICS

Division of UNITED AIRCRAFT AND TRANSPORT CORP.

BOEING SCHOOL OF AERONAUTICS
Room E-2, Airport, Oakland, California

Gentlemen: I am interested in

☐ Boeing Master Pilot
☐ Limited Commercial Pilot
☐ Private Pilot
☐ Boeing Master Mechanic
☐ Transport Pilot
☐ Special Master Pilot
(*Open to holders of Transport Licenses*)

Name_____ Age_____
Years in High School_____ Years in College_____
Address_____
City_____ State_____

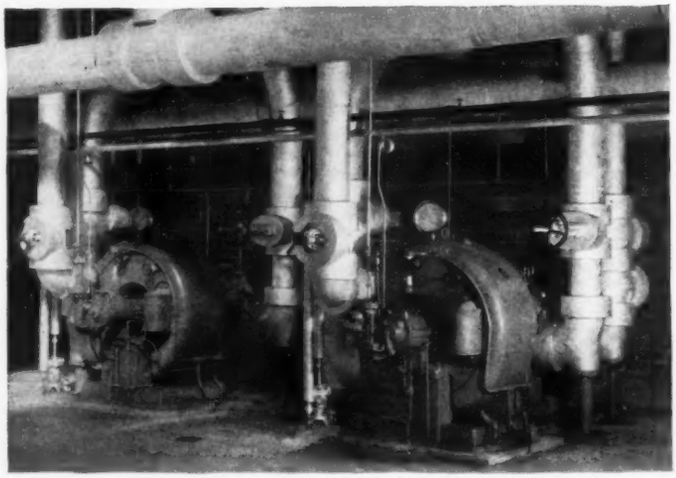
TERRY

8 TERRY SOLID WHEEL TURBINES SERVE ASHTABULA STATION » »

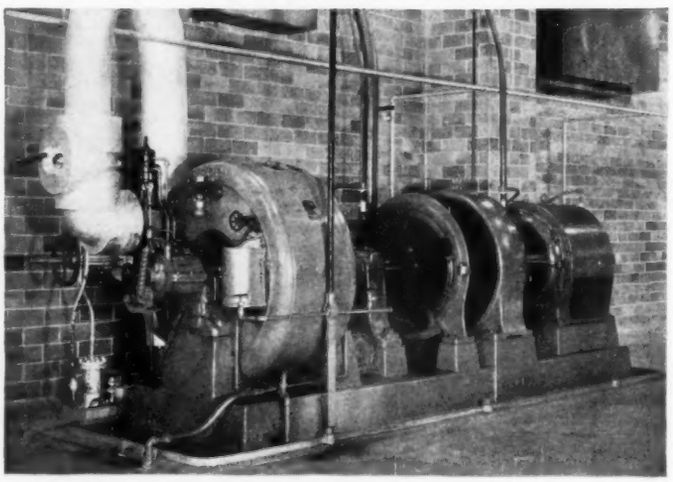
At Ashtabula, the newest station of the Cleveland Electric Illuminating Co., eight Terry turbines are used to drive essential auxiliaries.

These machines employ the solid one-piece Terry turbine wheel. The buckets are milled from the solid metal — not inserted.

The blades have large clearances and are further protected by projecting rims at the sides of the wheel, which would take without damage any rubbing that might occur if clearance became reduced. It is therefore impossible for the blades to foul.



Two 625 HP Terry turbines driving boiler feed pumps



300 KW Terry duplex exciter

Ask for bulletin S-84, which describes these durable turbines.

The TERRY Steam Turbine Co.

TERRY SQUARE, · · HARTFORD, CONNECTICUT

TURBINES, GEARS SHAFT COUPLINGS

T-1094

PROFESSIONAL SERVICE

RATE $2.00 per month to A.S.M.E. members, $2.50 per month to non-members, which includes name and address in Alphabetical List and one listing in Classified List. Additional listings $1.00 each per month to A.S.M.E. members, $1.25 each per month to non-members.

THE feature of this section is the Classified Index of specialists, which is arranged alphabetically by subject headings. The method of classification is to list by specific specialty offered and sub-list by function performed. The advice or services of experts thus is assured without delay or confusion.

When seeking information about a given specialty, for example, regarding a Steam Power Plant, look under "POWER PLANTS, STEAM" and under this heading and its subheadings are listed those specializing in the design, location, supervision, layout, test, etc., of such a project. Select one or more names and refer to the Alphabetical List in the center of the page for addresses.

CONSULTING ENGINEERS • ENGINEERING ORGANIZATIONS • CONSTRUCTORS—CONTRACTORS • PATENT LAWYERS • ETC.

CLASSIFIED INDEX

TO SPECIALIZED SERVICES OFFERED

Accounting Systems (Installations)
Scovell, Wellington & Co.

Alkali Manufacturing Plants (Operation)
Ahlqvist, Harald

Appraisals
(See Industrial Plants, Power Plants, etc.)

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Scovell, Wellington & Co.

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Murray, Thomas E. (Inc.)

Buildings, General (Design)
Murray, Thomas E. (Inc.)

Chemical Analysis
Pitkin, Lucius (Inc.)

Civil (General)
(See Specific Specialty)

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Fuel Engineering Co. of New York
Murray, Thomas E. (Inc.)

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(See Specific Specialty)

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(See Specific Specialty)

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(See Specific Type desired)

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Fuel Engineering Co. of New York

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(See Specific Specialty)

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Pitkin, Lucius (Inc.)

Metallurgical Research
Pitkin, Lucius (Inc.)

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(See Specific Specialty)

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Harald Ahlqvist, 331 Madison Ave., New York, N. Y.

Sterling P. Buck, 629 F Street, N.W., Washington, D. C. Tel. District 3863.

Fuel Engineering Co. of New York, 116 East 18th Street, New York, N. Y.

P. E. Harrison & Co., Masonic Bldg., Dover, N. H.

Everett E. Kent, 75 Federal St., Boston, Mass. Tel. Hubbard 0234.

Robert E. Kinkead, 3441 Lee Road, Cleveland, Ohio.

A. A. Langewald, Jr., 86 Essex St., Boston, Mass.

Thomas E. Murray, Inc., 88 Lexington Ave., New York, N. Y.

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Cyrus Wm. Rice & Co., Inc., Highland Bldg., Pittsburgh, Pa.

Sargent & Lundy, Inc., 20 North Wacker Drive, Chicago, Ill.

Scovell, Wellington & Co., 10 East 40th Street, New York, N. Y. Other Offices—Boston, Springfield, Mass., Syracuse, Philadelphia, Cleveland, Chicago, Kansas City, San Francisco.

Maxwell E. Sparrow, 1482 Broadway, New York, N. Y.

John A. Stevens, Inc., 16 Shattuck St., Lowell, Mass.

E. P. Worden, 1 Hamilton Road, Glen Ridge, N. J.

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(See Buildings)

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(See Specific Specialty)

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Kent, Everett E.
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Kent, Everett E.

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Buck, Sterling P.
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Worden, E. P.

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Soda Mfg Plants, Caustic (Operation)
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(See Appraisals, also Specific Properties)

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Rice, Cyrus Wm., & Co. (Inc.)

Water Supply Methods
Rice, Cyrus Wm., & Co. (Inc.)

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Kinkead, Robert E.

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Businesses For Sale
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Manufacturing Facilities

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Help Wanted—Positions Wanted
Equipment, Material, Patents,
Books, Instruments, etc.
Wanted and For Sale

RATES Classified advertisements under this heading in MECHANICAL ENGINEERING are inserted at the rate of 60 cents a line. 50 cents a line to members of A.S.M.E. Seven words to the line average. A box number address counts as one line. Minimum insertion charge, 5 line basis, maximum 20 lines. Display matter carried in single column units of multiples of one inch at the flat rate of $10. per inch per insertion. Copy must be in hand not later than the 10th of the month preceding date of publication.

HELP WANTED

RESEARCH POSITION—Man wanted to meet following requirements: The work may be classed as engineering research, engineering development, or practical physics as needed in the development of instruments and instrument applications. The instruments manufactured are widely used by industrial plants, by the medical profession and by the general public. Most of the instruments are mechanically actuated in the broad sense of the word and a large part of them are used to measure or control temperature or pressure. It is desired that the man be a graduate engineer or physicist with at least several years' experience or a man that has received a doctor's degree, either with or without further experience. Good personality, initiative and the ability to proceed independently with a development project are important qualifications. Address CA-72, care of "Mechanical Engineering."

WANTED: EXPERIENCED HYDRAULIC ENGINEER, capable of designing HYDRAULIC PRESSES, PUMPS and VALVES; with sales ability. State age, experience and salary. Address CA-70, care of "Mechanical Engineering."

POSITIONS WANTED

GRADUATE MECHANICAL ENGINEER—wants job in France for American concern—French citizen—37—married—one child—12 years in U.S.A. Has been Engineer Designer with Westinghouse, Carnegie Steel, Mesta Machine—in Pittsburgh district. Can design machinery small or big. Has been Master Mechanic with Fairmount Aluminum Co. Address CA-74, care of "Mechanical Engineering."

MECHANICAL ENGINEER; four years practical experience including shop-practice, design of automatic machinery and testing of plant equipment in Germany and U.S.A. Diplom-Ingenieur Charlottenburg, M.S. in M.E. Columbia University. Age 29, single. Address CA-71, care of "Mechanical Engineering."

ASSISTANT TO EXECUTIVE, member A.S.M.E., University Graduate, Prof. Eng. License N. Y. State, experienced in research, development, design of equipment for and operation, organization, management of chemical, sugar and allied plants, appraisals and reports, French and German languages, wants position. Address CA-69, care of "Mechanical Engineering."

ASSISTANT TO FACTORY MANAGER: Broad experience in design, production control, shop and power plant in metal working plants and electric public utilities. Graduate M.E. with special E.E. and C.E. training. Address CA-68, care of "Mechanical Engineering."

REPRESENTATIVES AVAILABLE

EUROPE—Mechanical Engineers established in Holland with good connections and thorough knowledge of Europe wish to contact sound American Company with specialized products desirous of entering European market either by export or manufacture under license. Address CA-73, care of "Mechanical Engineering."

MANUFACTURERS REPRESENTATIVES, Sales Engineers desire additional lines to sell to industrial concerns, power plants, etc., in Pittsburgh district. Our salesmen cover Pennsylvania west of Harrisburg, West Virginia and Ohio. Very best connections. Address CA-63, care of "Mechanical Engineering."

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ENGINEER: MANUFACTURER: SPECIAL services in PATENT matters, I offer you at modest fees. Sterling P. Buck, a Patent Attorney; Registered 27 years in U. S. Patent Office; Registered in Canadian Patent Office; prompt, adaptive, persistent, thorough. Washington Permanent Bldg., Washington, D.C.

JOHN P. NIKONOW, Mechanical and Electrical Engineer, Registered Patent Attorney. Member A.S.M.E., A.I.E.E., S.A.E., El.Chem. Soc. Patents in all countries. Consulting service on scientific and designing problems. 3425 Giles Place, New York, N. Y.

PATENT LAWYER, MAXWELL E. SPARROW, Patent, Trade-mark, and Copyright Cases, 1482 Broadway, New York, N. Y.

EDWARD GOTTLIEB, REGISTERED PATENT ATTORNEY, Associate Member A.S.M.E. Expert in patent causes. Consultations invited without obligation. Low fees, send for price list of charges. 5 Beekman Street, New York, N. Y.

Use a CLASSIFIED ADVERTISEMENT
for Quick Results

BUSINESS OPPORTUNITIES

MECHANICAL ENGINEER — forty-two — abroad — available United States February or June—wishes then to interview a manufacturing executive, confronted with inefficient plant operating problems and interested in securing someone suitable, to: investigate technically his power and manufacturing conditions, recommend resulting profitable possibilities, and execute approved projects into operation. Negotiations confidential. Address CA-65, care of "Mechanical Engineering."

RESEARCH by well-known engineer has resulted in new process and machine revolutionizing staple industry. $15,000 will equip and operate plant to earn $25,000 to $50,000 net annually. F. A. W., care of C. W. Baker, 90 West St., New York, N. Y.

EMPLOYMENT AGENCIES AND SERVICE BUREAUS

E. G. Stroud, Member A.S.M.E., President The Cleveland Engineering Agency Co., 219 Huron-Ninth Building, Cleveland, Ohio, has for 30 years been engaged in technical placement work. Employers wishing to engage Executives, Engineers, Designers, Draftsmen or other technical men are invited to use this service. Applicants available should write for blank and list of opportunities.

SALARIED POSITIONS
$2,500 to $25,000

This thoroughly organized advertising service of 24 years' recognized standing and reputation carries on preliminary negotiations for positions of the caliber indicated, through a procedure individualized to each client's personal requirements. Several weeks are required to negotiate and each individual must finance the moderate cost of his own campaign. Retaining fee protected by a refund provision as stipulated in our agreement. Identity is covered and, if employed, present position protected. If you have actually earned over $2,500, send only name and address for details. R. W. Bixby, Inc., 115 Delward Building, Buffalo, N. Y.

It will pay you to watch the announcements on this page for an opportunity that you may be looking for or one that may be of interest to you.

BUT IT'S FAIR AND WARM BY TELEPHONE!

Outside, hurrying feet plod on against the winds and swirling snow of winter. On such a day, it is good to be indoors where all is snug and warm.

• • •

ALL outdoors may be frowning, the thermometer close to zero, street travel an exhausting task. Yet to your telephone it is as clear and fair as a day in June.

Without moving from your chair at home or in your office, you can send your voice across the snow-swept miles. Wind and weather need not delay the necessary tasks of business or break the ties between friends and relatives. Through all the days of the year, the telephone is your contact with the world beyond your door. It knows no season—no letting up when the going gets hard. Through storm and flood, an army of trained employees works ceaselessly along the highways of speech.

This very day, as you talk so easily from the warmth and comfort of your home, a lineman may be scaling a pole far out on a frozen mountainside—so that the service may go on. So that you may talk to almost anyone, anywhere, at any time.

Make someone happy these winter days through a voice visit by telephone. A boy or girl at school, a mother or father in another city, or a good friend away on a visit. To most places 175 miles away, for example, the rate for a station-to-station call is 95c in the daytime, 85c after 7 P. M., and 55c after 8:30 P. M.

BELL TELEPHONE SYSTEM

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*Cramp Brass and Iron Foundries Co. 15
Paschall Station, Philadelphia, Pa.

*DeLaval Steam Turbine Co..... 25
Trenton, N. J.
Diamond Chain & Mfg. Co..... —
413 Kentucky Ave., Indianapolis, Ind.

Engineering Building..... —
205 West Wacker Drive, Chicago, Ill.

Advertising Forms of MECHANICAL ENGINEERING close on the sixth of the month preceding date of issue.

Space reservation for advertisements to appear in the March issue should reach us not later than February 6th, copy and cuts by February 10th.

Ethyl Gasoline Corp'n..... —
Chrysler Bldg., New York, N. Y.

*Garlock Packing Co..... —
Palmyra, N. Y.
*General Electric Co..... —
Schenectady, N. Y.
*Gwilliam Company..... 14
360 Furman Street, Brooklyn, N. Y.

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*Jenkins Bros..... —
80 White St., New York, N. Y.
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*Lincoln Electric Co..... 3
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Marlin-Rockwell Corp'n.....*3rd Cover*
Jamestown, N. Y.

*National Meter Co..... 2
4205 First Ave., Brooklyn, N. Y.

*Republic Flow Meters Co..... 4
2232 Diversey Parkway, Chicago, Ill.
*Robertson, John, Co. (Inc.)..... 2
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*S K F Industries (Inc.)..... 13
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*Shakeproof Lock Washer Co..... 14
2511 North Keeler Ave., Chicago, Ill.
*Simplex Valve & Meter Co..... —
6753 Upland Street, Philadelphia, Pa.
Smooth-On Mfg. Co..... 2
570 Communipaw Ave., Jersey City, N. J.
Socony Vacuum Corp'n. (*Insert*)7, 8, 9, 10
26 Broadway, New York, N. Y.
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Canton, Ohio

Union Carbide and Carbon Corp'n. 11
205 East 42nd Street, New York, N. Y.

*Wickes Boiler Co..... —
Saginaw, Mich.

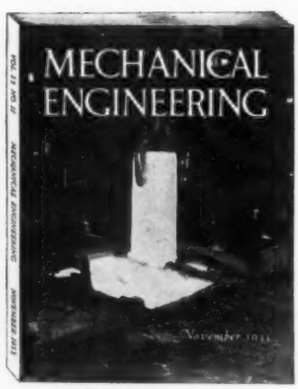
Asterisk (*) before a name indicates that firm has an abridged catalog in the 1933-34 Mechanical Catalog

Read by the VITAL Factors in Industrial Buying

THE broad scope of MECHANICAL ENGINEERING is evident from the articles which appear in each issue. Practically all feature articles come from prominent scientists, engineers, and industrial economists . . . and because of this, MECHANICAL ENGINEERING does a job that is not duplicated by any other publication.

It is a far-reaching job, from engineering and industrial standpoints, and consequently offers a means of effectively reaching industry at large (and the actual buyers and specifiers of industrial apparatus) in a very economical manner.

Apparatus and materials advertised in MECHANICAL ENGINEERING are exposed to the men who have the ability, through training and experience, to evaluate them intelligently. It will, therefore, pay your firm to give serious consideration to its consistent use for promoting the sale of their products.



Compound geared turbine propelling unit on the tanker G. *HARRISON SMITH*, with De Laval double reduction worm turning over gear.

DE LAVAL WORM GEARS *to drive* MEDIUM AND SLOW SPEED MACHINERY

Vertical shaft, propeller type condenser circulating pump driven by a steam turbine through a De Laval worm gear.

1075

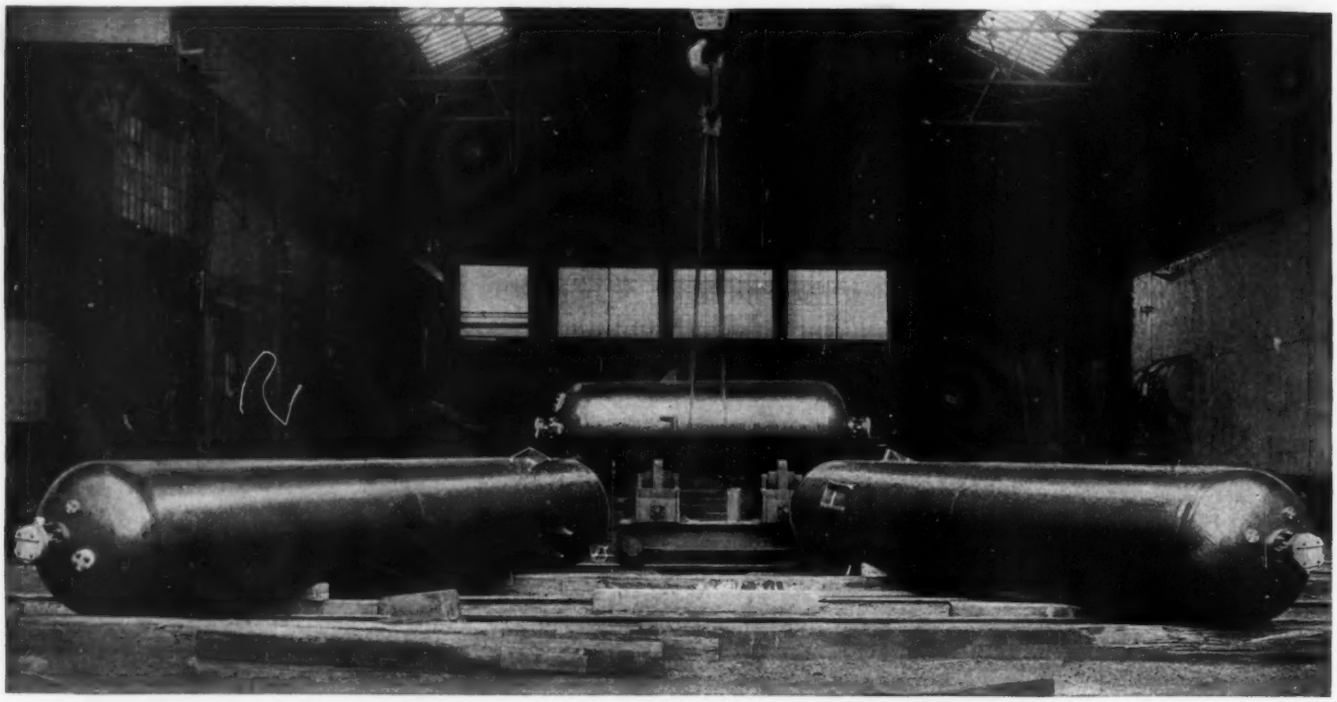
Pumps, fans, compressors, conveyors, hoists, etc., can be driven most reliably and efficiently by small and inexpensive standard speed or high speed electric motors, or by steam turbines, through De Laval worm gear speed reducers.

The De Laval Worm Gear is self-contained and self-lubricating and is immune to dirt, grit and moisture. It runs continuously in the most severe service, without attention other than checking the oil level at long intervals.

May we assist in the solution of your auxiliary drive problems?

DE LAVAL STEAM TURBINE COMPANY

TRENTON • NEW JERSEY



View on Kellogg assembly floor showing 2 44" ID x 2-5/8" thick x 21' 10-7/8" liquid CO2 storage tanks, weight 31,000 lbs. each tested to 3000 lbs. and one 44" ID x 1-3/4" thick x 12' 2-3/4" liquid CO2 expansion tank, weight 13,000 lbs. tested to 1200 lbs.

KELLOGG MASTERWELD DUCTILE TOUGH

KELLOGG PRESSURE VESSELS

accumulators
evaporators
digesters
heat exchangers
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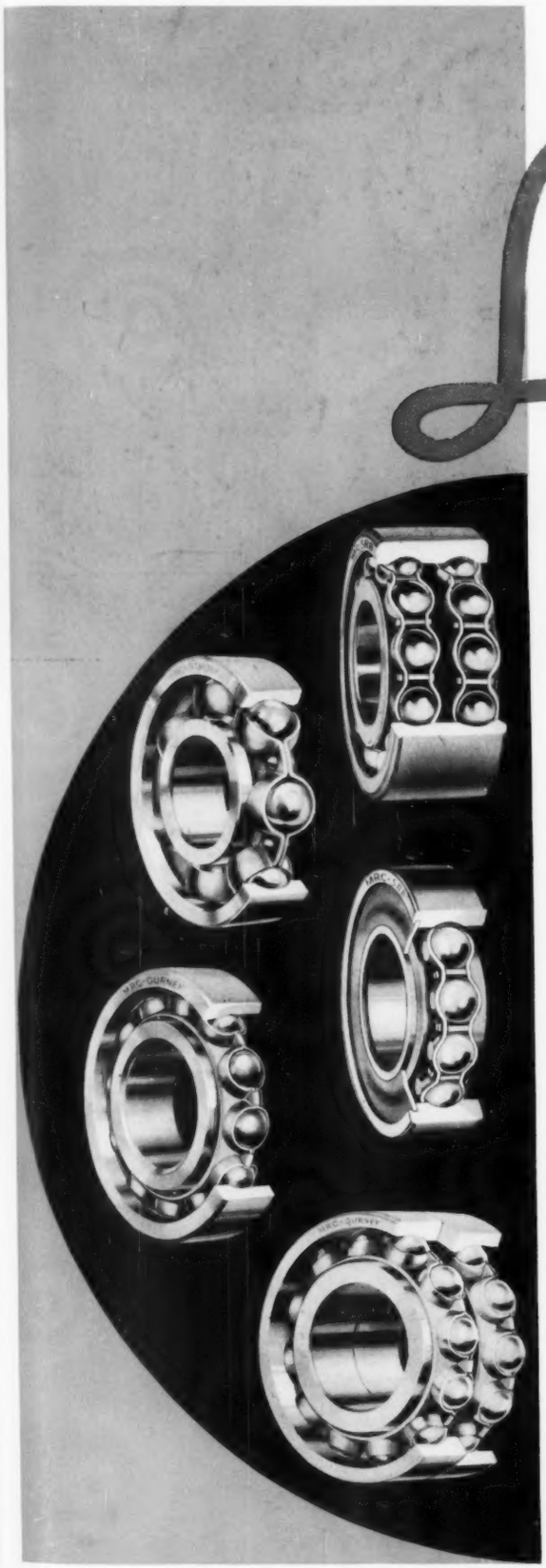

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